U.S. Fish & Wildlife Service

Status of Selected Cyprinid Species and Gear Selectivity at Historic Lower Missouri River Sampling Sites

The objectives of this study were to compare the abundance of selected Missouri River chubs and minnows to historical data and to compare seining and bottom trawling efforts in the Lower Missouri River. Nine of thirteen historic collection sites and two new sites were seined and trawled in the Missouri River during July and August 1997. Higher than average river levels prevented sampling three historic sites between Kansas City and the Iowa border. Sixty sicklefin chubs (Macrhybopsis meeki), 29 sturgeon chubs (M. gelida), and 676 plains minnows (Hybognathus placitus) were collected. No flathead chubs (Platygobio gracilis) or Western silvery minnows (Hybognathus argyritis) were collected. Benthic trawling was more successful in capturing sicklefin chubs and sturgeon chubs while seining was the more effective technique in catching plains minnows. The chub and minnow community of the Lower Missouri River may be more adequately sampled when using a combination of shallow water and benthic gears. Analysis of sampling data from 1944 to 1997 indicated a decline in the presence of flathead chubs and Western silvery minnows and an increase in the presence of sicklefin chubs. The probability of collecting sturgeon chubs remained stable over time. Results of trend analysis in plains minnow data were less clear. Plains minnows declined from 57% of total catch in 1940-1945 to 0.1% of total catch in 1994 but rebounded to 15% in 1997.

Status of Selected Cyprinid Species at Historic Lower Missouri River Sampling Sites

Prepared by

Joanne M. Grady
and Jim Milligan

Columbia Fisheries Resources Office
U.S. Fish and Wildlife Service
Columbia, MO

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"From an aesthetic point of view, the Missouri River has an unenviable reputation. People who never see it except in crossing...bridges, from which they look down into a mass of muddy, eddying water, are liable to compare it unfavorably with other important streams."
"But to him who is fortunate enough to travel upon it, and study it in all its phases, it is not only an attractive stream, but one of great scenic beauty."

Hiram Martin Chittenden,
History of Early Steamboat Navigation on the Missouri River

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Introduction

The pre-settlement Missouri River was characterized by high turbidity, wide seasonal variations in flow and a shifting braided channel. Some fish species which evolved in this environment are not well adapted for today's Missouri River which has been channelized, straightened, impounded, and polluted. Cyprinid species of concern include: sicklefin chub (*Macrhybopsis meeki*), sturgeon chub (*Macrhybopsis gelida*), flathead chub (*Platygobio gracilis*), plains minnow (*Hybognathus placitus*), and western silvery minnow (*Hybognathus argyritis*).

Pflieger and Grace (1987) reviewed fish data from the Lower Missouri River collected at 20 year intervals from the 1940s through the 1980s. Flathead chubs were most numerous in the Missouri River in Missouri during 1940-1945. Flathead chubs have since declined in abundance and could become extirpated in the lower river. Pflieger and Grace (1987) showed a decline in abundance of plains minnows and western silvery minnows between the 1940-1945 and the 1978-1983 sampling periods in the Missouri River in Missouri. The plains minnow was less abundant in the lower reaches of the Missouri River in Missouri in 1978-1983 than in the upper reaches. Sicklefin chub and sturgeon chub populations increased downstream of Kansas City over the sixty year time period. Pflieger and Grace (1987) hypothesized that channelization had increased their preferred habitat, open channels with swift current and firm substrates. Sicklefin and sturgeon chubs were rare in the Missouri River above Kansas City in the 1980s.

Hesse (1994) found that sicklefin and sturgeon chubs had declined dramatically in abundance in the Lower Missouri River in Nebraska. Sicklefin, sturgeon, and flathead chubs were not collected in the unchannelized reach below Gavins Point dam from 1983 through 1993. Hesse (1994) determined that flathead chub relative abundance in the unchannelized reach had declined by 98% while plains and western silvery minnows had declined by 96%.

On June 29, 1994 the U.S. Fish and Wildlife Service was petitioned by American Rivers, the Environmental Defense Fund, the Mni Sose Intertribal Water Rights Coalition, the Audubon Society, and the Nebraska Audubon Council to list the sicklefin and sturgeon chubs as endangered species under authority of the Endangered Species Act of 1973. Following the petition, Gelwicks (1996) examined historically sampled study sites along the Missouri River in Missouri. Samples collected by Gelwicks (1996) did not suggest a decline in the distribution or abundance of sicklefin and sturgeon chubs in the Missouri River in Missouri. Low numbers of flathead chubs, plains minnows, and western silvery minnows did suggest, however, that these species were continuing to decline.

Gelwicks et al (1996) recommended that the status survey for sicklefin chub, sturgeon chub, and flathead chub in the Missouri River, Missouri be repeated at the same time of year at which Pflieger and Grace (1987) sampled the river. It was also recommended that future sampling efforts incorporate the use of a benthic trawl to sample fish in deep-water habitats per Grisak (1996). Grisak used a benthic trawling technique developed in the Columbia River on Missouri River reaches in Montana. More sicklefin chubs were collected by trawling in the deeper water zone than by seining in the littoral zone.

This study was conducted to determine if there were differences in fish catch rates between seines and bottom trawls at historic sampling sites in the Lower Missouri River, Missouri. This study will also aid the U.S. Fish and Wildlife Service in determining if any of the above mentioned chub and minnow species warranted listing as federally endangered species.

Methods

Nine of the thirteen locations sampled by Grace and Pflieger (1985) and Gelwicks et al (1996) were sampled between July 24 and August 28, 1997 (Figure 1). Three sites historically sampled above Kansas City, Missouri and one site at Lexington, Missouri could not be sampled due to high water. The historic sampling sites were numbered sequentially in a downstream direction. Site 1 occured near the Missouri/Iowa border while Site 13 occured near the confluence with the Mississippi River (Figure 1). Two sites with similar habitat were added to the study. Site 14 is a large channel bar located at River Mile (RM) 23.7-24.5R, upstream of historic Site 13. Site 15 is a large channel bar complex located at RM 216.5-217.0R, adjacent to the Lisbon Bottoms unit of the Big Muddy National Fish and Wildlife Refuge. Both channel bars are large and persistent enough to be recorded on U.S. Army Corps of Engineers River and Harbor Project maps (U.S. Army Corps of Engineers 1996).

Seining in the Missouri River / USFWS

Benthic trawling on the Missouri River / USFWS

All sites were composed of channel bars, connected bars, and channel margins as described in Gelwicks et al (1996) (Figure 2). Sampling efforts could not be assigned via random stratification of different habitat and substrate types due to high water. Any and all available areas were sampled. Missouri River stages at seven river gages are compared to CRP in Figure 3. CRP is the gauge reading of the Construction Reference Plane, an imaginary sloping line, established for structure height reference. CRP is approximately equal to normal navigation stage. River stages at all gages within the study area exceeded CRP throughout the summer of 1997 (Figure 3).

Fish were sampled using a 7.6-m (25-ft) long, 2.4-m (8-ft) deep drag seine with 6-mm (1/4-in) mesh similar to that used by Grace and Pflieger (1985) and Gelwicks et al (1996). Fish were also sampled with a benthic trawl equipped with a roller rock lead line and the following dimensions: 2-m (6.4 ft) wide, 0.5-m (1.6 ft) high, 5.5-m (18 ft) long, 0.32-cm (1/8 in) inner mesh, 3.81-cm (1.5 in) outer chafing mesh, and 16.5-cm (6.5 in) cod-end opening. Trawling was conducted from the bow of the boat while travelling downstream with the engine in reverse. The engine speed was slightly faster than the flow of the river to keep the trawl inflated.

Hourly river stages at the nearest upstream gaging stations were obtained from the U.S. Army Corps of Engineers Reservoir Control Center web page (http://www.mrd.usace.army.mil). The start and end points of each seine or bottom trawl haul were marked with a Global Positioning Unit. Distance sampled was determined by computer from these two points. Total area sampled per seine and total volume per bottom trawl were then estimated. A Marsh-McBirney current velocity meter was used to measure bottom velocities at the midpoints of both seine and bottom trawl sites as well as columnar velocity at the midpoint of bottom trawl sites. Surface water temperature, turbidity, and conductivity were measured at the midpoints of each sampling site when this equipment was available. Depth of benthic trawl samples was measured with a Hummingbird depth finder.

All fishes, except for readily identifiable adults of large species were preserved in 10% formalin for laboratory identification and enumeration. Total lengths (mm) and weights (g) of each fish were measured in the laboratory.

Statistical analyses were conducted using the Statistical Analysis System (SAS 1991). The Shapiro-Wilk test was used to determine if sicklefin chub, sturgeon chub, and plains minnow numbers represented random samples from normal distributions (SAS Institute Inc. 1991, Zar 1984). A Kruskal-Wallis non-parametric analysis of variance (ANOVA) test was used to determine if there were significant differences in catch rates of sicklefin chub, sturgeon chub and plains minnows with respect to habitat type, substrate, mean depth and bottom velocity.

Long-term Missouri River datasets were examined to statistically determine if cyprinid species were increasing or decreasing in the Missouri River in Missouri. Fish samples from sites 1-13 dating to the 1940s were assigned a binary value of 1 for presence of a species and a value of 0 when a species was absent. Logistic regression analysis was used to model the relationship between the binary and the explanatory variables year, site, and (year and site) (SAS Institute, Inc. 1995). The (year and site) variable was included in the test to cover the potential compounded effect of year and site. For example, the probability of collecting a fish species may have declined over time. If the decline was caused by dam construction, the decline may have moved downstream as dam operation affected the river over time. (Note: the logistic regression test is not a cause and effect test.) Significance was determined at $P \leq 0.005$ for all tests. The Hosmer and Lemeshow goodness of fit test was used to determine if the data fit the model for each species.

Sites 14 and 15 were not used in this analysis because they were not sampled prior to 1997. Sites 1 through 13 were sequentially numbered in a downstream direction from the Missouri/Iowa border to the Mississippi River confluence. Therefore, the relationship between site and fish presence could be tested. A significant positive model would indicate the probability of collecting fish was greater downstream. A significant negative model would indicate the probability of collecting fish was greater upstream.

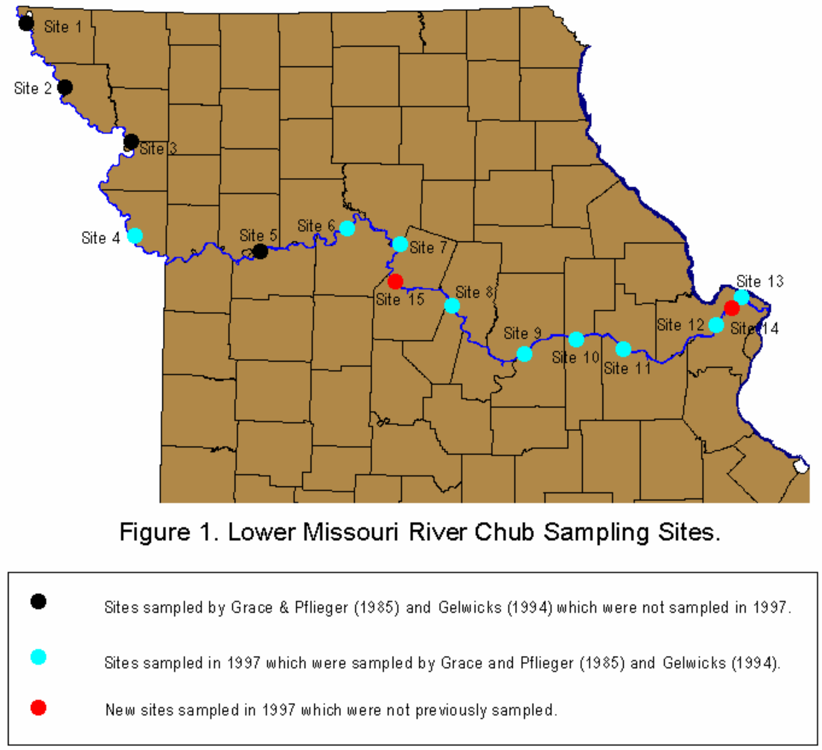

Figure 1. Lower Missouri River Chub Sampling Sites.

Table 1. Locations of Missouri River Sampling Sites.

Sampling Site	Site Name	River Mile	Sample Date (1997)
1	Brownville, NE	536.0-540.4	None (due to high water)
2	Rulo, NE	498.9-505.9	None (due to high water)
3	St. Joseph, MO	454.0-459.3	None (due to high water)
4	Leavenworth, KS	391.0-395.0	August 12
5	Lexington, MO	319.7-342.2	None (due to high water)
6	Miami, MO	269.2-262.9	August 13
7	Glasgow, MO	231.9-227.0	August 14 and 28
8	Easley, MO	177.3-177.0	July 24
9	Bonnots Mill, MO	129.8-129.1	July 31
10	Gasconade, MO	100.8-99.5	August 1
11	Washington, MO	77.6-75.1	August 7
12	St. Charles, MO	34.9-31.3	August 6
13	Halls Ferry, MO	16.3-16.2	August 5
14	Carl's Island	24.5-23.7	August 5
15	outside Lisbon Bottoms chute	217.5-216.5	August 27

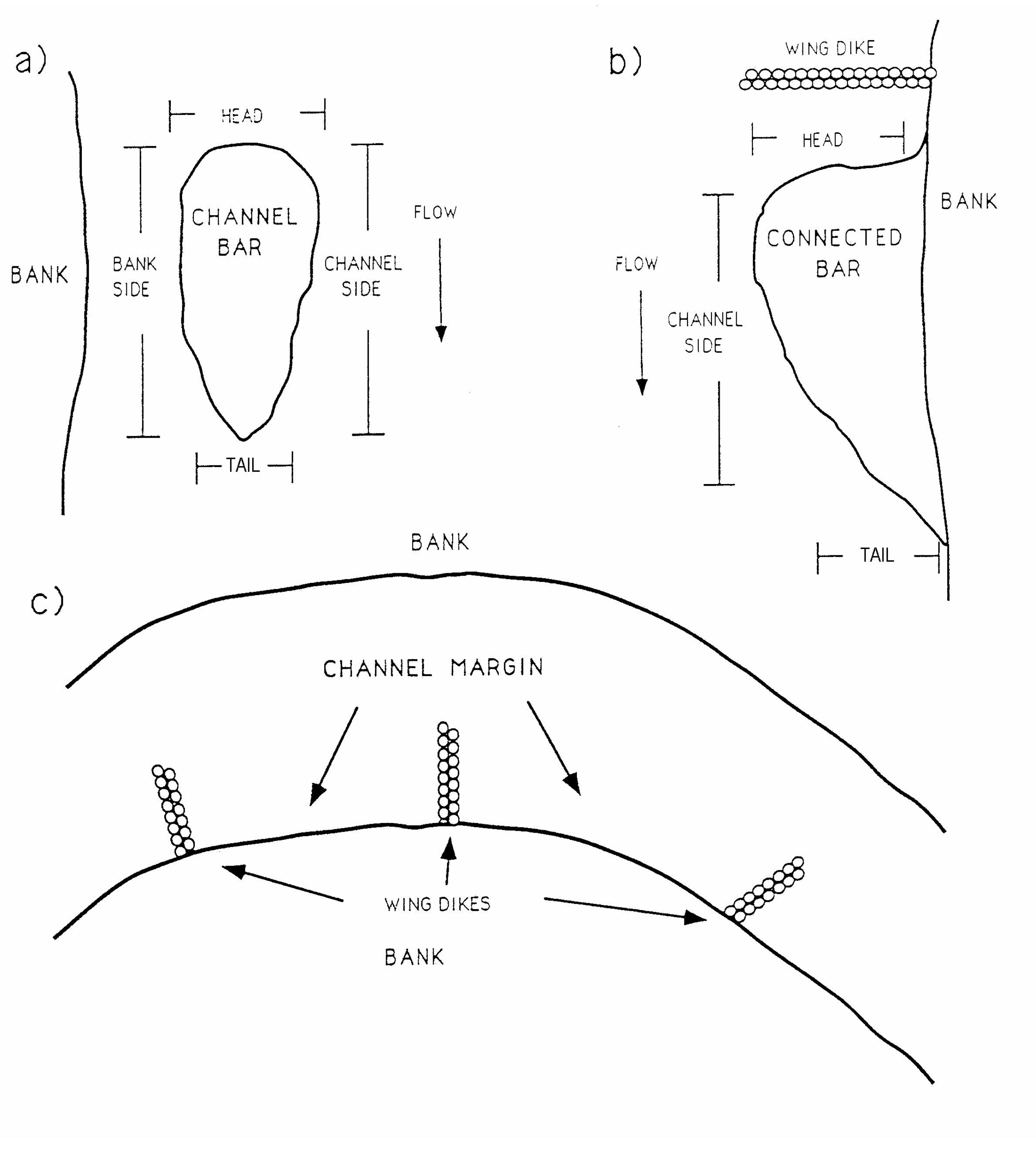

Figure 2. General habitats sampled on the Missouri River, MO in 1997; a) channel bar, b) connected bar, and c) channel margin (Gelwicks et al. 1996).

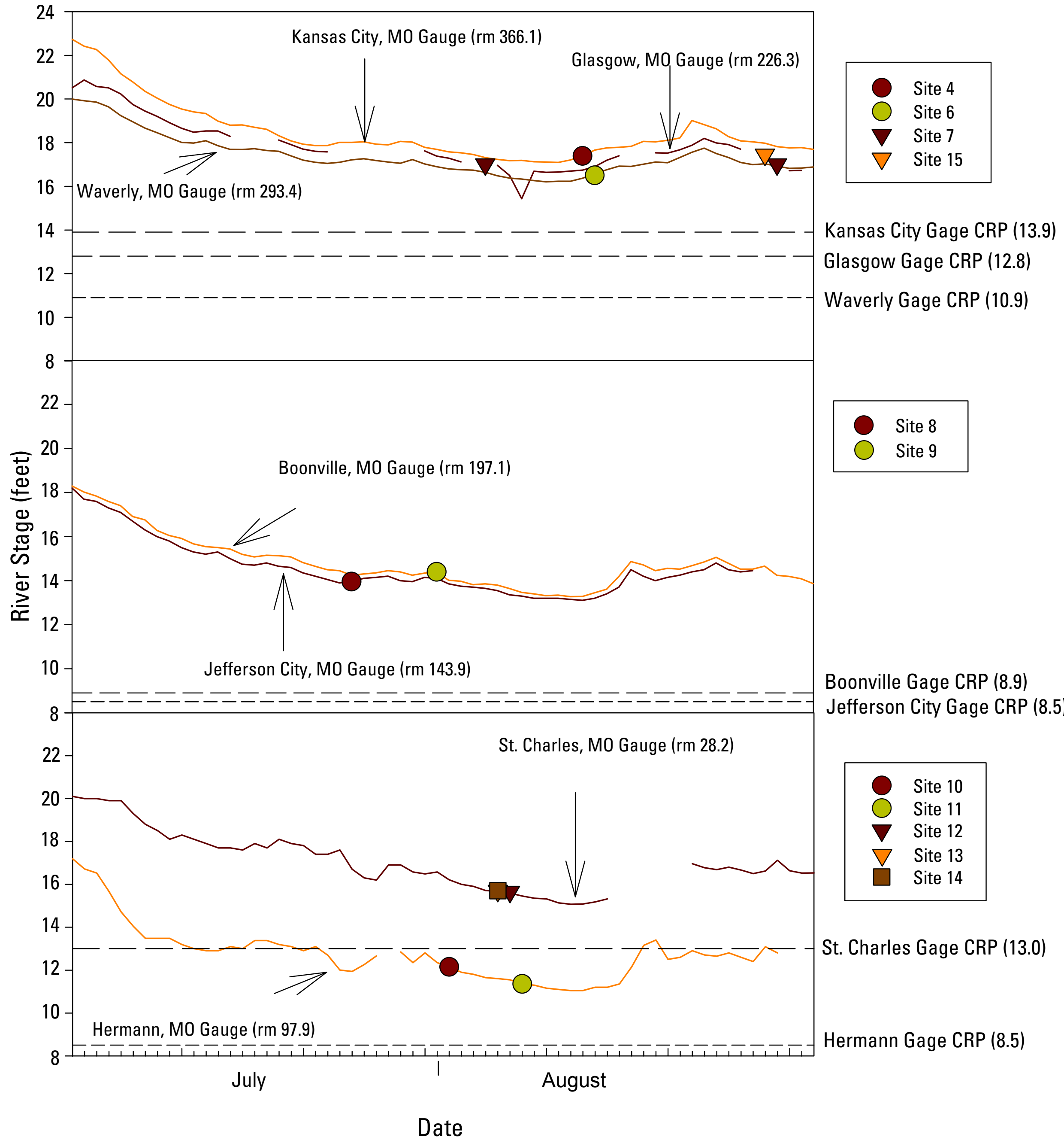

Figure 3. River stages at Lower Missouri river gages, July-August, 1997.

Results

Thirty-six species were represented in our collection of 4,638 fish (Table 2). River carpsucker and gizzard shad dominated the seine samples while channel catfish dominated the bottom trawl samples.

Seine

Thirty-one fish species represented by 3934 fish were collected in 56 seine hauls. Two to ten seine hauls were made at each site and the area seined in each sample ranged from 26.8 m^2 to 3858.4 m^2. The fish collected primarily represented species known to occur in midwater or surface schools, in quiet pools, or stream and river backwaters (Pflieger 1975).

Species that were collected only (or predominantly) in the seine included (numbers in parentheses indicate the percentage of this species collected by seining):

- longnose gar
- shortnose gar
- gizzard shad
- goldeye (93%)
- common carp
- silver chub (92%)
- red shiner
- emerald shiner
- river shiner
- ghost shiner
- sand shiner
- spotfin shiner
- bluntnose minnow (83%)
- plains minnow (99%)
- river carpsucker (99%)
- golden redhorse
- brook silverside
- mosquitofish
- spotted bass
- white bass
- green sunfish
- sauger
- freshwater drum (89%)

Benthic Trawl

Thirteen fish species represented by 704 fish were collected in 31 benthic trawl samples. One to seven benthic trawl samples were collected at each site with the exception of site 14 which was not sampled by trawling. The volume of each benthic trawl sample ranged from 6.3 m^3 to 757.7 m^3. The fish collected primarily represented species known to occur on or near the bottom of large rivers (Pflieger 1975).

Species that were collected only (or predominantly) in the trawl included (numbers in parentheses indicate the percentage of this species collected by trawling):

- shovelnose sturgeon
- sicklefin chub (98%)
- speckled chub
- sturgeon chub
- blue catfish
- channel catfish (94%)
- flathead catfish

Significant differences were found in logistic regression models for several target and non-target species. This indicated that either year, site, or the combined effect of year and site produced either a positive or negative change in the probability of catching these fish throughout the 1940s to 1990s sampling period. The specific results for each species are covered in the following pages. These fish included:

- sicklefin chub
- plains minnow
- flathead chub
- western silvery minnow
- emerald shiner
- sand shiner
- bluntnose minnow
- bigmouth shiner
- river shiner and
- ghost shiner.

No significant differences were found between year, site, or year and site and the probability of collecting one target and several non-target species. This indicates that the probability of collecting these fish over time and across sites remained relatively stable. There was no increasing or decreasing trend detected. These species included:

- sturgeon chub
- silver chub
- spotfin shiner
- red shiner
- speckled chub
- central stoneroller

Efforts were made to use the Hosmer and Lemeshow goodness of fit test to determine if the data fit the model for each species. However, most of the expected frequencies were less than five rendering the test results questionable and unusable.

Table 2. Fish collected in seine and benthic trawl samples in the Missouri River, Missouri from July 24, 1997 to August 28, 1997.

Species	Site 4 391.0-395.0		Site 6 269.2-262.9		Site 7 231.9-227.0		Site 8 177.3-177.0		Site 9 129.8-129.1		Site 10 100.8-99.5		Site 11 77.6-75.1		Site 12 34.9-31.3		Site 13 16.3-16.2		Site 14 24.5-23.7		Site 15 213.0-212.0		TOTALS		
	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Total
Blue Catfish						2				16		9						5						32	32
Bigmouth Buffalo									1														1		1
Bluegill					1																		1		1
Bigmouth Shiner					1																		1		1
Bluntnose Minnow															1		2	1	2				5	1	6
Brook Silverside													2										2		2
Common Carp							1		3										1				5		5
Channel Catfish	1	12		31	1	35		41	12	265	2	118	2	1	1	1	1	29	3		9		32	533	565
Central Stoneroller													1										1		1
Emerald Shiner	28		6		9		7		8		2		37		62		6		2		77		244		244
Flathead Catfish						10		3		2		1			1	1							1	17	18
Freshwater Drum	1		4	4		1	1		14												22		42	5	47
Ghost Shiner									2														2		2
Goldeye										1	38	1	3					1					41	3	44
Golden Redhorse											1												1		1
Green Sunfish			1										1								2		4		4
Gizzard Shad	2		25		18		46		120		31		165		502		85		165		11		1170		1170
Hybognathus sp.							1																1		1
Shovelnose Sturgeon						2				11				1				1						15	15
Longnose Gar			1				3						1										5		5
Mosquitofish									2		3				3								8		8
Plains Minnow	82		1		25		15		157		9		42		2		231		1		109	2	674	2	676
River Carpsucker	14		1			1	96	1	64		152		4		117		811		20		172		1451	2	1453
Red Shiner	4				2								8		1		65				1		81		81
River Shiner	1						2				1						2						6		6
Sauger	2																						2		2
Sand Shiner	68		3		2		3				1		4		8		7		3		7		106		106
Spotfin Shiner	1																						1		1
Sicklefin Chub						2				36		14		3	1			4					1	59	60
Skipjack Herring																			1				1		1
Silver Chub	10	1		1					4		1		1		2				5		1		24	2	26
Shortnose Gar					1																		1		1
Spotted Bass											1		1				2						4		4
Speckled Chub						1		1		1														3	3
Sturgeon Chub						28				1														29	29
White Bass	2						6		1				1		3				1		1		15		15
unidentifiable fish												1												1	1
TOTALS	216	13	42	36	60	82	181	46	388	333	242	144	273	5	704	2	1212	41	204	0	412	2	3934	704	4638

Target Fish Species

Sicklefin Chub *Macrhybopsis meeki*

Photo courtesy of Bill Pflieger, Missouri Department of Conservation

Sicklefin chubs were collected from sites 7, 9, 10, 11, and 13 in the benthic trawl and in the seine at site 12. Sicklefin chubs were most abundant at site 10 at 8.81 fish/m^3. They were collected in 36% of the trawl samples and 2% of the seine samples. Sicklefin chubs comprised 8% of the trawl catch and 1.3% of the total catch. They were the second most abundant fish collected in trawls, following channel catfish (76%).

Sicklefin chubs were collected most frequently from the channel sides of channel bars (76.7% of sicklefin chubs collected). They were also collected on the channel side of connected bars (8.3%), the bank side of channel bars (6.7%), the main channel border with wing dykes (5%), backwater shorelines (1.7%), and the unstructured main channel (1.7%). However, no significant difference in habitat type was detected for sicklefin chub with the Kruskal-Wallace nonparametric analysis of variance test. Although sicklefin chubs were collected in a wide range of bottom velocities, sixty percent of the collected chubs were in water with a bottom velocity of 0.61-0.8 m/s. This was a statistically significant difference in velocity ($P=0.0057$, $F=2.536$, $df=6$). Seventy percent of the sicklefin chubs were collected in water 1.5-2.0 m in depth. This was a statistically significant difference in depth ($P=0.0269$, $F=2.536$, $df=6$). There was a significant difference in substrate use ($P=0.0280$, $F=3.285$, $df=3$) by sicklefin chubs with 46.7% collected over organic matter. Twenty-three percent were collected over silt while 6.7% were collected over a gravel/rock substrate.

Sicklefin chubs ranged in size from 16 to 89 mm total length (Figure 4). Adult sicklefin chubs are typically 61-94 mm long with a maximum length of 102 mm (Pflieger 1975).

Logistic regression analysis indicated a significant positive relationship ($P=0.0029$) between (year and site) and the probability of collecting sicklefin chubs. The probability of collecting sicklefin chubs increased over time and as sampling sites moved downstream (Figure 5). Pflieger (1997) noted the sicklefin chub is far more abundant between Boone County(~RM 120) and the confluence with the Mississippi River than upstream of Kansas City (RM 366). Long-term data analysis supports this conclusion.

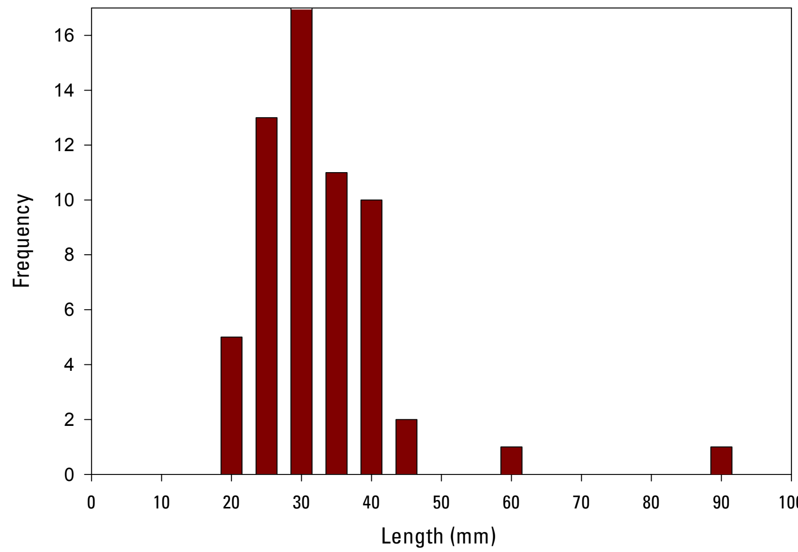

Figure 4. Length frequency of sicklefin chubs collected by seining and benthic trawling in the Lower Missouri River in 1997.

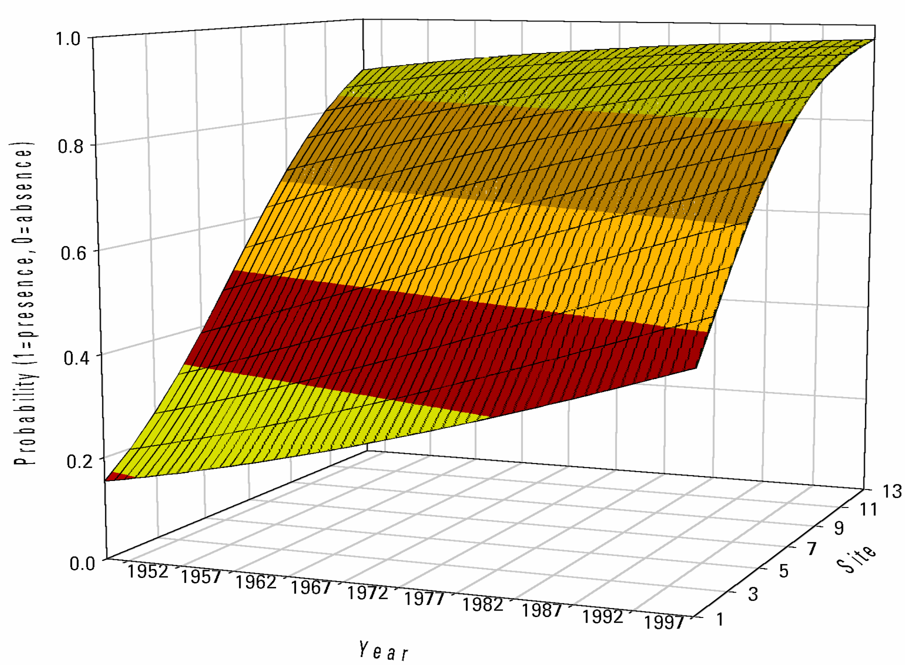

Figure 5. Probability of collecting sicklefin chubs in the Missouri River from 1945 to 1997 (Probability = Pi/1+Pi; logit(Pi) = - 57.8414 + 0.0287(year) + 0.3120(site)).

Sturgeon Chub *Macrhybopsis gelida*

Sturgeon chubs were collected by benthic trawl at sites 7 and 9 and were present in 6.5% of the trawl samples. They were the fourth most abundant fish in trawl samples, comprising 4% of the trawl catch and 0.6% of the total catch.

Sturgeon chubs were only collected in two locations. Twenty-eight of the 29 sturgeon chubs were collected on the channel side of a connected bar. This site contained a gravel/rock substrate, a bottom velocity of 0.85 m/s, and a mean depth of 1.68 m. The remaining chub was collected on the channel side of a channel bar with a coarse particulate organic matter substrate. This site had a bottom velocity of 0.76 m/s and a mean depth of 1.68 m.

Sturgeon chubs ranged in size from 23 to 56 mm total length (Figure 4). Sturgeon chubs are typically 43-64 mm long with a maximum length of 76 mm (Pflieger 1975).

No significant differences were found in the presence of sturgeon chubs in Missouri River samples across sites or over time. This indicates the probability of collecting a sturgeon chub neither increased nor decreased in the Missouri River from 1945 to 1997. Pflieger (1997) noted this species was rare in the 1940s but had become more common in the lower 300 river miles. Pflieger (1997) postulated that Missouri River dam construction had reduced the river's silt load providing more of the sturgeon chub's preferred gravel substrate.

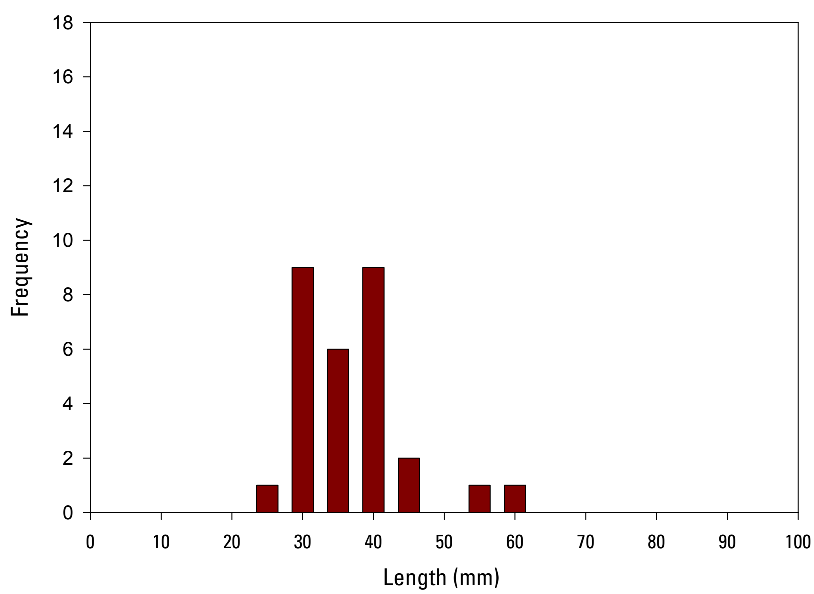

Figure 6. Length frequency of sturgeon chubs collected by benthic trawling in the Lower Missouri River in 1997.

Plains minnows were collected at all sites by seining and in the benthic trawl at site 15. The plains minnow was most abundant at site 13 at 64.3 fish/ m^2.They were present in 58% of the seine samples and 6.5% of the trawl samples. They represented 17% of the seine catch and 15% of the total catch. The plains minnow was the third most abundant fish in seine samples, following river carpsucker (37%) and gizzard shad (30%). Gelwicks et al (1996) only collected 4 plains minnows at sites 4 and 5 while they were the most abundant fish, representing 26% of the total fish, collected by Grace and Pflieger (1985).

All but two of the 676 plains minnows collected were caught in seines. Therefore, it's not surprising that 80.8% of these fish were collected in water with bottom velocities of 0-0.2 m/s and 89.1% were collected in water with a mean depth of 0-0.5m. Plains minnows were caught in a range of habitats. Forty-one percent of plains minnows were caught on the channel side of channel bars. Ninety-two percent of collected plains minnows were over a sand substrate. There were no significant differences detected in habitat, substrate, depth, and velocity for plains minnows with the Kruskal-Wallace nonparametric ANOVA.

Plains minnows ranged in size from 22 to 79 mm total length (Figure 7).

No significant differences were found in presence of plains minnows across sites or across (year and site). Logistic regression analysis did indicate a significant negative relationship (P=0.0091) between year and the probability of collecting plains minnows (Figure 8). Statistically, this relationship appears to be largely due to the lack of plains minnows in 1994 samples (Gelwicks et al 1996).

The Jaccard Index was utilized to determine the degree of association between past and present samples (Ludwig and Reynolds 1988). The formula used was:

$JI = a/(a+b+c)$

a - species was collected in both the present and the past

b - species was collected in the past but absent in the present

c - species was absent in the past and collected in the present

where past was defined as 1940s and 1960s and present was defined as 1980s and 1990s.

The Jaccard Index has a minimum value of 0, which would indicate the fish were never collected in both the present and the past, and a maximum value of 1, indicating the fish were always collected in both the present and the past.

When all thirteen historically sampled sites were considered

Photo courtesy of Matt Winston, Missouri Department of Conservation

the Jaccard Index was 0.77. When the sites which couldn't be sampled due to high water (Sites 1, 2, 3, and 5) were removed from consideration the Jaccard Index became 1. This indicates the Jaccard Index was also impacted by the lack of plains minnows in 1994 samples.

The logistic regression analysis and Jaccard Index were used to examine potential differences in the probability of collecting this species over time and not to test for differences in plains minnow numbers. There is no doubt that there are fewer plains minnow in the Missouri River. Pflieger (1997) noted "The plains minnow was the most abundant minnow in the upper Missouri River but has undergone a drastic decline which may be leading to its extirpation from Missouri." Continued sampling, particularly of the three most upstream sampling sites will aid in determining trends for this species.

It should be noted that further consultation indicates that the basioccipital process, used to differentiate plains minnow from Western silvery minnow and Mississippi silvery minnow, may not be fully developed and a reliable indicator before the fish reaches 50 mm in length (Mark Pegg and Doug Dieterman, personal communication). This raises the possibility that some of the fish identified as plains minnow in 1997 should more appropriately have been identified as *Hybognathus* sp.

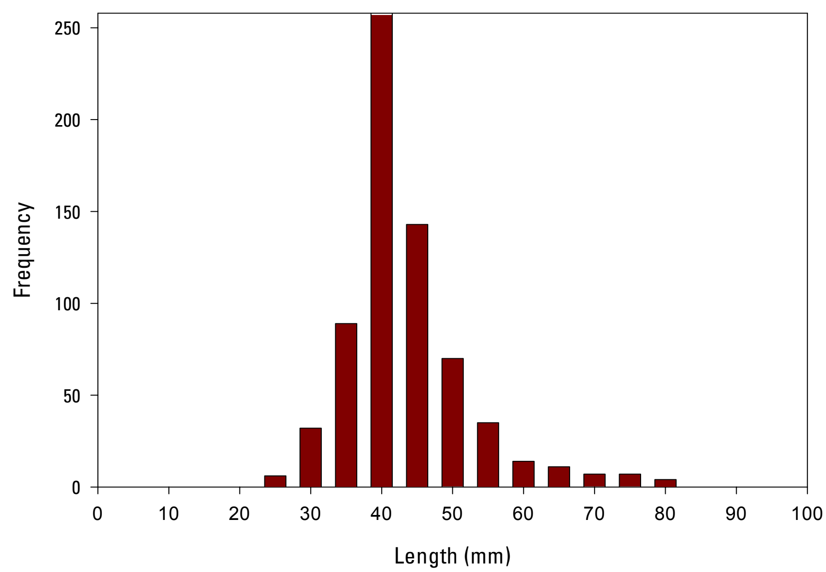

Figure 7. Length frequency of plains minnows collected by seining and benthic trawling in the Lower Missouri River in 1997.

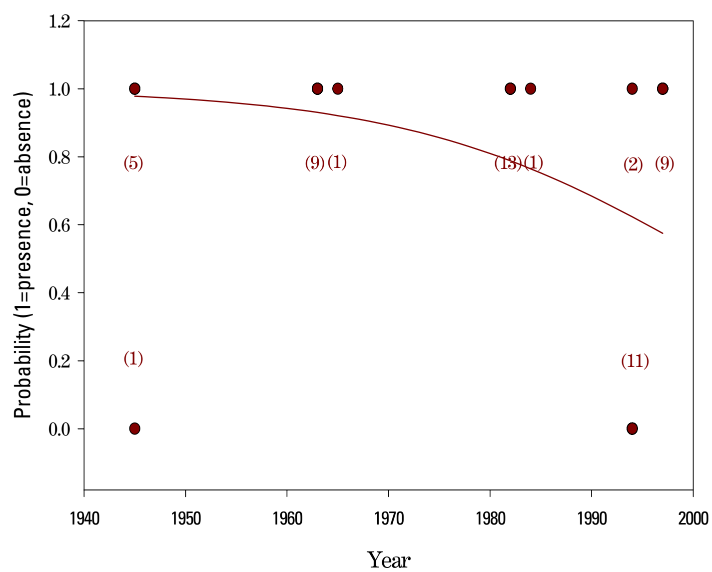

Figure 8. Presence vs. absence of plains minnows in Missouri River samples from 1945 through 1997 and probability of catching this species over time (probability = odds/1+odds, log(odds)=134.9-0.0674(year), P=0.0091). Numbers in parentheses indicate the number of samples represented by a dot.

Flathead Chub *Hybopsis gracilis*

No flathead chubs were collected in 1997. Gelwicks (1994) collected 1 flathead chub at site 4. Grace and Pflieger (1985) collected flathead chubs at all sites but 5, 10, and 12.

The probability of collecting flathead chubs declined dramatically over time in the Missouri River (Figure 9). Logistic regression analysis indicated a significant negative relationship between (year and site) and the probability of collecting flathead chubs.

Flathead chub decline coincided with Missouri River dam construction and full system regulation which occurred in the mid-1960s. Dam construction and operation modified the Missouri River hydrograph and decreased turbidity. Decreased turbidity benefitted sight-feeding species such as the emerald shiner to the detriment of the flathead chub.

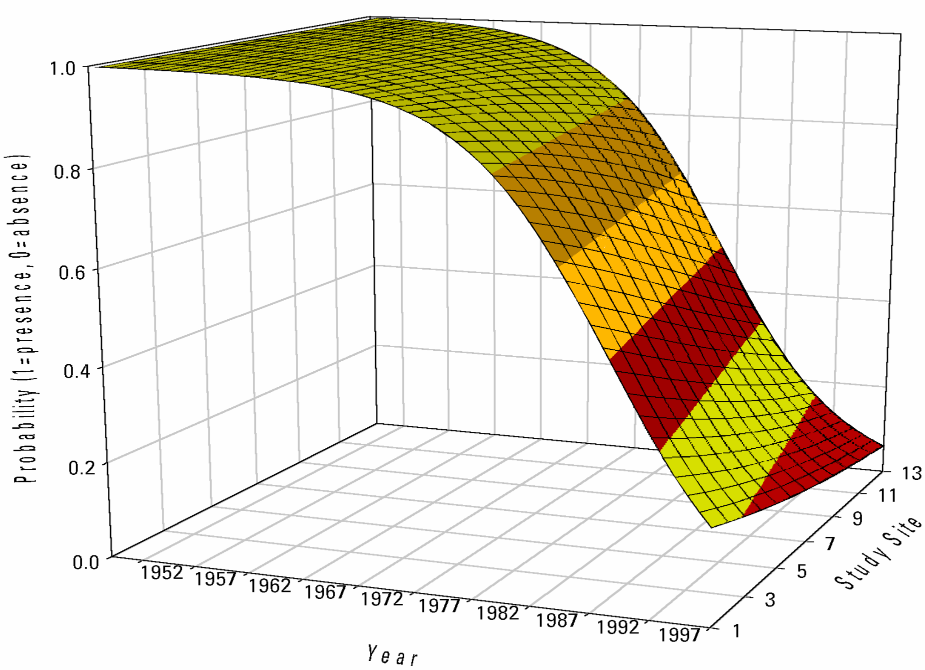

Figure 9. Probability of collecting flathead chubs in the Missouri River from 1945 through 1997. (Probability = Pi/1+Pi; logit(Pi) = 331.0 - 0.1664(year) - 0.1100(site)).

Western Silvery Minnow *Hybognathus argyritis*

No western silvery minnows were collected in 1997. Gelwicks et al (1996) collected 13 western silvery minnows at sites 1 through 5. Grace and Pflieger (1985) collected them at all sites except 3 and 13.

Logistic regression analysis indicated a significant negative relationship (P=0.0013) between (year and site) and the probability of collecting Western silvery minnows. The probability of collecting this species declined from 1945 to 1997 and as sampling efforts moved downstream (Figure 10). Pflieger (1997) noted that this species had undergone a drastic decline in distribution and abundance and may soon be extirpated from Missouri. These data support that hypothesis.

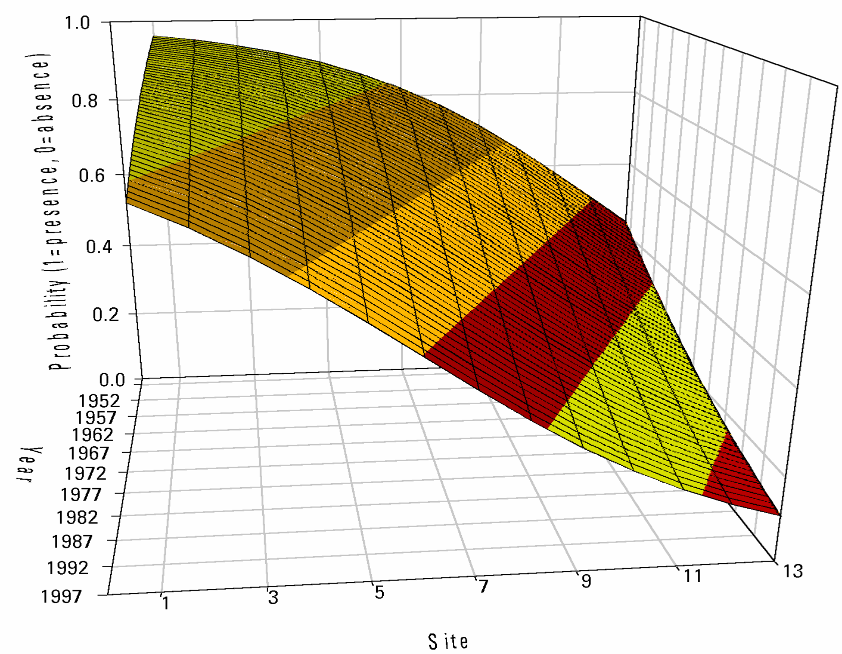

Figure 10. Probability of collecting Western silvery minnow in the Missouri River from 1945 through 1997 (Probability = Pi/1+Pi; logit(Pi) = 72.0691 - 0.0352(year) - 0.2980(site)).

Long-term Trends in Non-Target Species

Sand Shiner *Notropis stramineus*

Logistic regression analysis indicated a significant positive relationship (P=0.0051) between (year and site) and the probability of collecting sand shiners. The probability of collecting sand shiners in the Missouri River increased from 1945 to 1997 (Figure 11). The probability of collecting sand shiners across sites changed over time. The probability was higher upstream in the 1940s. The probability of collecting sand shiners was higher downstream in the 1990s. Pflieger (1997) noted the sand shiner is uncommon in the Missouri and Mississippi rivers and shows a strong affinity for sandy bottoms.

Photo courtesy of Matt Winston, Missouri Department of Conservation

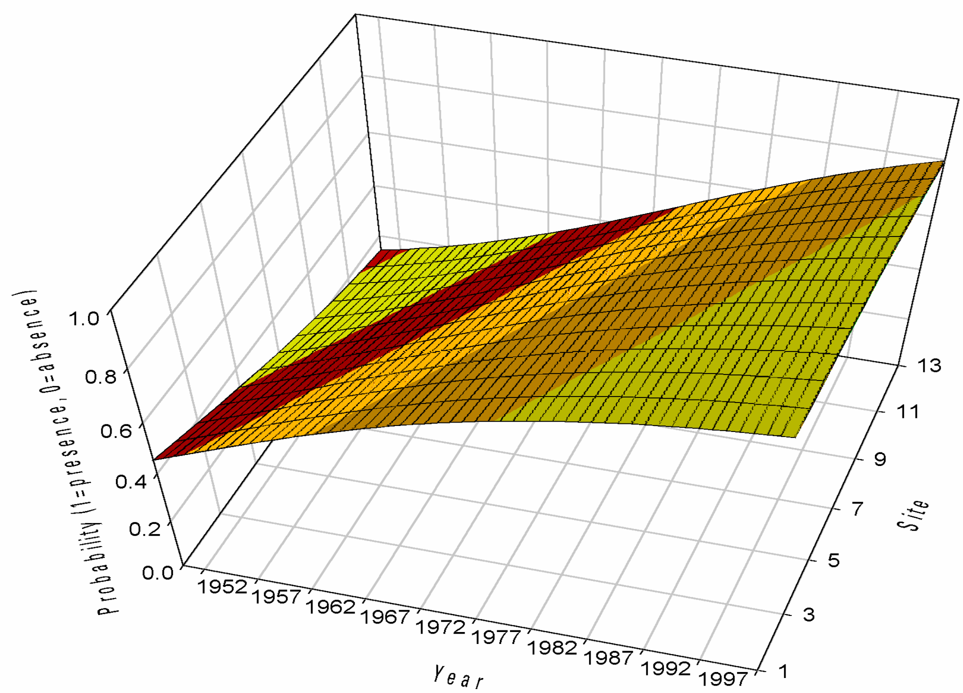

Figure 11. Probability of collecting sand shiners in the Missouri River from 1945 to 1997 (Probability = Pi/1+Pi; logit(Pi) = -118.3 + 0.0608(year) - 0.1351(site)).

Ghost Shiner *Notropis buchanani*

Pflieger (1997) noted the ghost shiner was common in the lower Missouri River but had disappeared from the upper Missouri River. Logistic regression analysis confirmed this with a significant negative relationship (P=0.0058) between (year and site) and the probability of collecting ghost shiners. The probability of collecting ghost shiners in the Missouri River decreased over time (Figure 12). The probability of collecting ghost shiners was higher downstream from 1945 to 1997 (Figure 12). This species inhabits protected backwaters with little current.

Photo courtesy of Matt Winston, Missouri Department of Conservation

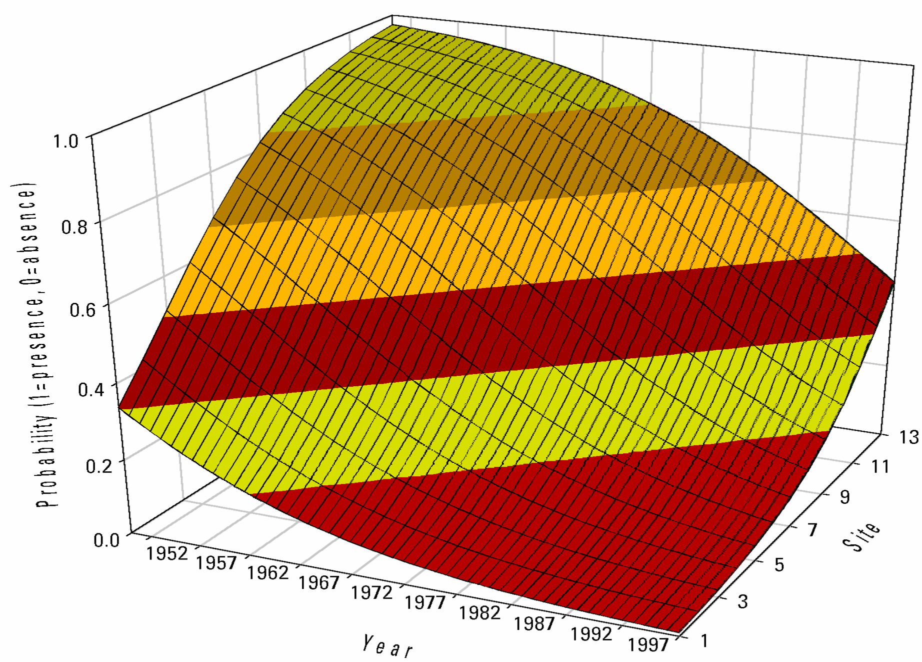

Figure 12. Probability of collecting ghost shiner in the Missouri River from 1945 to 1997 (Probability = Pi/1+Pi; logit(Pi) = 146.2 - 0.0757(year) + 0.3623(site)).

River Shiner *Notropis blennius*

Logistic regression analysis indicated a significant positive relationship (P=0.0022) between (year and site) and the probability of collecting river shiners. The probability of collecting river shiners in the Missouri River increased from 1945 to 1997 (Figure 13). The probability of collecting river shiners was greater upstream through time (Figure 13). The river shiner occurs almost exclusively in the Missouri and Mississippi Rivers and has progressively increased over the last 50 years (Pflieger 1997). Pflieger (1997) found this species was more common upstream of Lexington, Missouri (RM 317.3) than below.

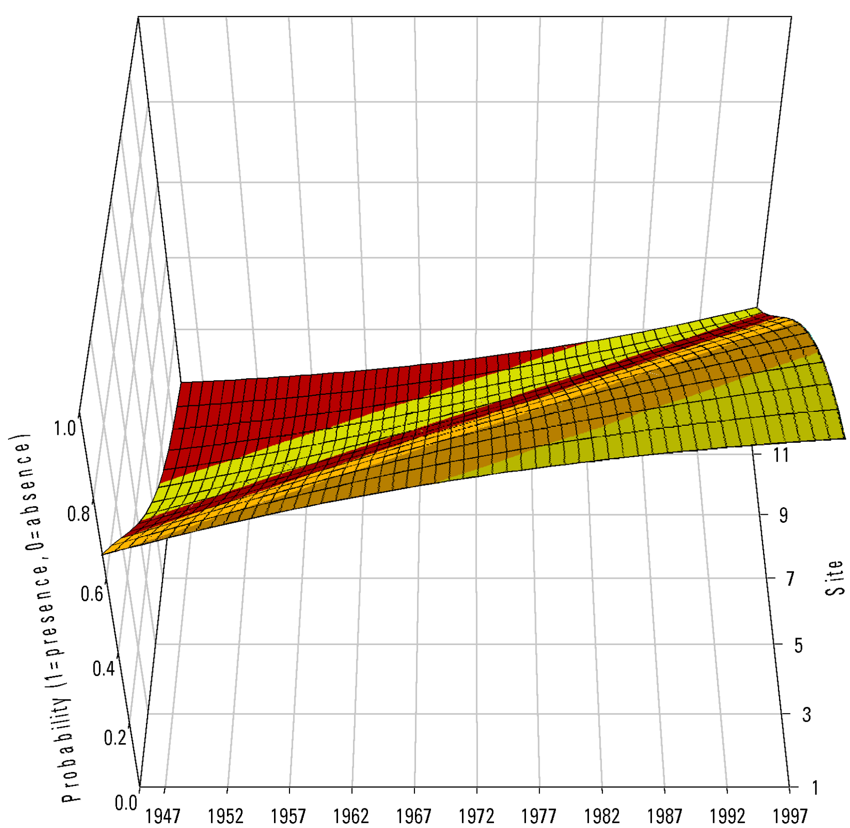

Figure 13. Probability of collecting river shiners in the Missouri River from 1945 to 1997 (Probability = Pi/1+Pi; logit(Pi) = -77.2198 + 0.0402(year) - 0.3147(site)).

Emerald Shiner *Notropis atherinoides*

This species is the most abundant minnow in the Missouri and Mississippi Rivers (Pflieger 1997). The probability of collecting emerald shiners increased dramatically in the Missouri River (Figure 14). Logistic regression analysis indicated a significant positive relationship (P=0.0001) between (year and site) and the probability of collecting emerald shiners. Increases in this sight-feeding species in the Missouri River may be due to reductions in turbidity which occurred as a result of dam construction and system operation. Hesse (1994) found this species increased from 17% to 69% of the cyprinid population in the Missouri River in Nebraska from 1971 to 1990.

Photo courtesy of Matt Winston, Missouri Department of Conservation

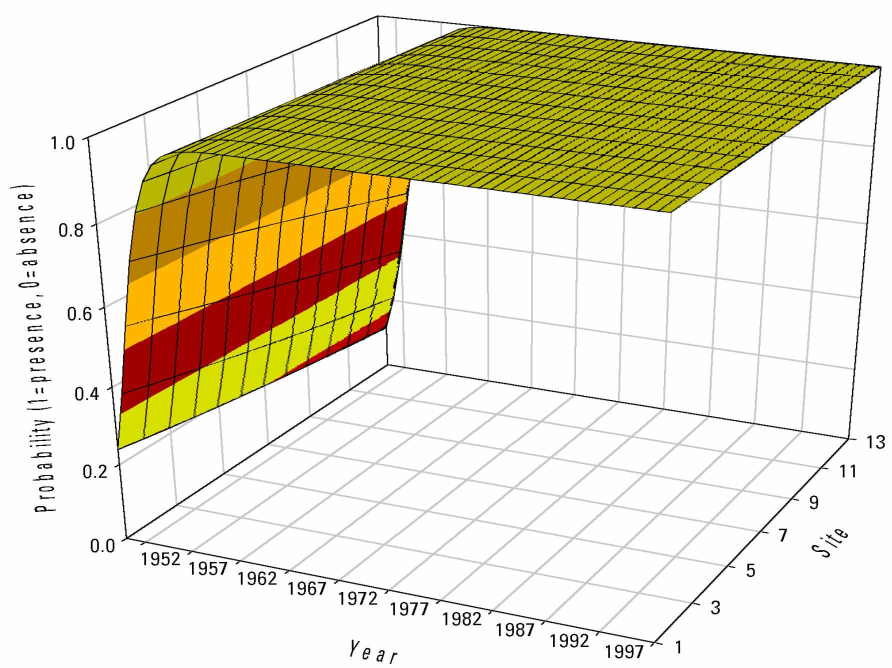

Figure 14. Probability of collecting emerald shiners in the Missouri River from 1945 to 1997 (Probability = Pi/1+Pi; logit(Pi) = -1372.9 + 0.7053(year) - 0.0723(site)).

Bigmouth Shiner *Notropis dorsalis*

Logistic regression analysis indicated a significant positive relationship (P=0.0164) between (year and site) and the probability of collecting bigmouth shiners in the Missouri River. The probability of collecting this species increased slightly over time (Figure 15). The probability of collecting bigmouth shiners was higher upstream from 1945 to 1997 (Figure 15). The probability of collecting this species in the Missouri River has never been very high (Figure 15). It is most abundant in small streams with permanent flow and shifting, sandy bottoms (Pflieger 1997). It is found in shallow water with a slight current.

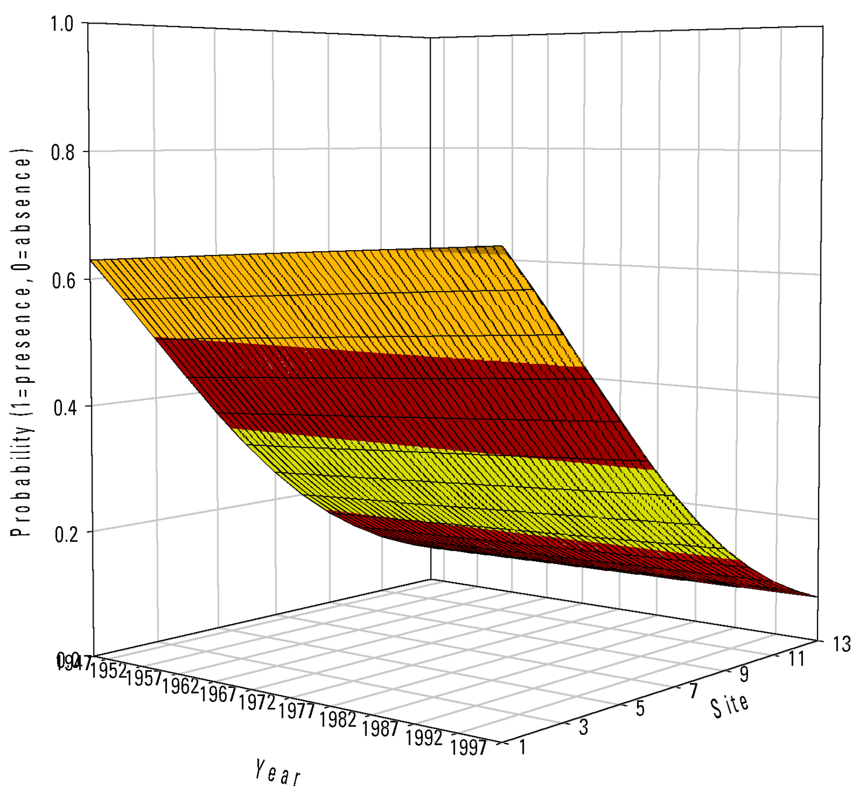

Figure 15. Probability of collecting bigmouth shiners in the Missouri River from 1945 to 1997 (Probability = Pi/1+Pi; logit(Pi) = -7.3022 + 0.00417(year) - 0.2748(site)).

Bluntnose Minnow *Pimephales notatus*

Logistic regression analysis indicated a significant negative relationship (P=0.0001) between (year and site) and the probability of collecting bluntnose minnows in the Missouri River. The probability of collecting bluntnose minnow in the Missouri River decreased over time. The probability of collecting this species within any given year increased as sampling efforts approached the mouth (Figure 16).

Bluntnose minnows are most abundant in quiet backwaters of medium to large streams with clear warm waters, permanent flows and some aquatic vegetation (Pflieger 1997).

Photo courtesy of Matt Winston, Missouri Department of Conservation

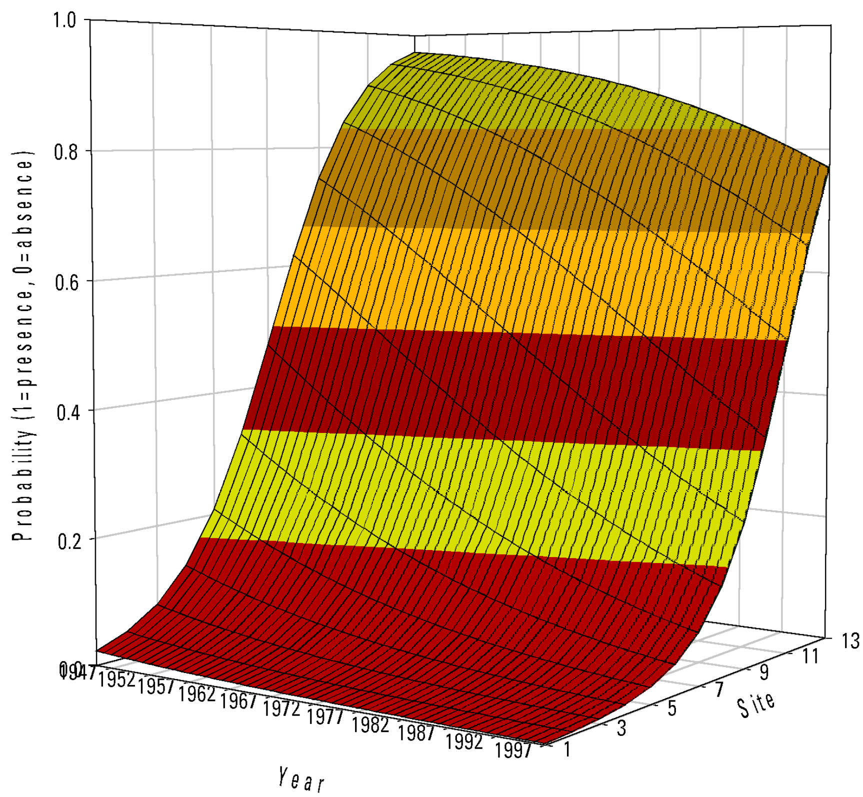

Figure ~~15~~ 16. Probability of collecting bluntnose minnows in the Missouri River from 1945 to 1997 (Probability = Pi/1+Pi; logit(Pi) = -7.3022 + 0.00417(year) - 0.2748(site)).

Discussion

1997 Sampling Efforts

Sampling efforts in 1997 were hampered to some extent by high water levels. Samples could not be collected at site 1, 2, 3 and 5 due to high water. Limited habitat availability at most other sites prevented conducting a randomly stratified survey. All available areas were sampled.

Results were similar to Gelwicks et al (1996) in that sicklefin and sturgeon chubs were collected while flathead chubs and western silvery minnows were not. Unlike Gelwicks et al (1996) the plains minnow was the third most abundant fish in seine samples and was collected at all sites. Plains minnow catch differences may be due to the timing of the samples. Gelwicks et al (1996) sampled for chubs in early November. It is possible the fish may have moved to a habitat not sampled with the seine. It is also possible that increased catch rates in 1997 may be due to the high water years of the mid-1990s which may have benefited this species by providing more backwater habitats.

No significant differences in habitat use were detected for any of the target species. Significant differences in depth, velocity, and substrate use were only detected for the sicklefin chub. Forty-seven percent of sicklefin chubs collected were over an organic matter substrate. Seventy-percent of collected sicklefin chubs were in water 1.5-2.0 m deep while sixty percent were in water with a bottom velocity of 0.61-0.8 m/s. Gelwicks et al (1996) collected sicklefin chubs mostly over sand and gravel substrates and in water velocities less than 0.35 m/s. Differences in habitat variable preferences in 1994 and 1997 appear to be due primarily to gear type. Most sicklefin chubs collected in 1997 were caught in the benthic trawl. Sampling efforts in "normal" water years will aid in continued evaulation of population trends and habitat preferences of the target species.

Long-term data analysis

The primary purpose of this study was to aid in determining if populations of the target fish species, sicklefin chub, sturgeon chub, flathead chub, plains minnow and western silvery minnow were declining. Efforts to statistically evaluate numbers of fishes sampled over time were hampered by the lack of sampling effort data from early Missouri River samples. A logistic regression test of the binomial "presence vs. absence" variable tested for trends in fish distribution over time and across sites but not for trends in fish abundance.

The most obvious assessment is that the flathead chub population has declined dramatically. Flathead chubs comprised 31% of the total catch of small fishes in Missouri prior to the completion of the Missouri River dams and the Bank Stabilization and Navigation Project. Average annual sediment loading in the lower Missouri River decreased by 81% after closure of the main stem dams (Slizeski et al 1982). The flathead chub is well-adapted to inhabit highly turbid streams. It depends on external taste buds more than sight to locate food (Pflieger 1997). Decreasing turbidity levels benefit sight-feeding cyprinids such as the emerald shiner to the detriment of the flathead chub (Pflieger 1997). Despite extensive Missouri River sampling by various researchers, only five flathead chubs have been captured since 1995 (Tibbs 1997).

There was no significant increase or decrease in the probability of collecting sturgeon chubs in the lower Missouri River in Missouri from 1945 to 1997. The percentage of sturgeon chubs in the total catch appeared to be consistent with numbers collected since the 1940s. Although the sturgeon chub population appears stable in the lower Missouri River in Missouri, it has declined dramatically throughout most of its range due primarily to changes in the river's channel, turbidity and hydrograph (Hesse 1994, Werdon 1993b).

Cross (1967) suggested the sicklefin chub was so specialized for life in a large turbid river that impoundments and modifications to the Missouri River would threaten its survival. With the exception of the lower Missouri River in Missouri, catches of sicklefin chub have been so rare the species may be in danger of extinction (Werdon 1993a). In Nebraska sicklefin chubs, sturgeon chubs, and flathead chubs were not collected in seining efforts upstream of Lewis and Clark Lake or in the lower unchannelized reach from 1983 to 1993 (Hesse 1994). The probability of collecting sicklefin chubs in the lower Missouri River in Missouri increased from 1945 to 1997. This population of sicklefin chubs may be better able to maintain itself due to the reduced effects of upstream impoundments on the river hydrograph. Tributary inflows moderate the impacts of reservoir regulation in the lowermost river reaches.

The probability of collecting plains minnows and western silvery minnows declined from 1945 to 1997. Catches of both species declined precipitously in the Missouri River in Missouri and in Nebraska (Hesse 1994, Pflieger and Grace 1987). Plains minnows historically comprised 1/3 or more of the total catch. The plains minnow inhabits mostly shallow sand bar habitat on the margins of the main channel (Hesse 1994). The apparent increase in plains minnows from 1994 to 1997 may be due to the high water and flood events which occurred in the Missouri River in 1993 and 1995-1997. The western silvery minnow inhabits backwaters or protected areas with low current and silty bottoms (Hesse 1994). Both of these habitat types declined dramatically with the channeling, straightening, and impounding of the Missouri River. The bluntnose minnow and ghost shiner also prefer quiet protected backwaters and declined from 1945 to 1997.

Literature Cited

Cross, F.B. 1967. Handbook of fishes of Kansas. Lawrence, University of Kansas, Museum of Natural History, Publication No. 45:357 pp.

Fisher, H. 1945. Report on the fisheries survey of the lower Missouri River, April 8, 1945-October 31, 1945. Missouri Conservation Commission, Division of Fish, Game, and Forests, Fisheries Section. 81 pp.

Fisher, H.J. 1962. Some fishes of the lower Missouri River. American Midland Naturalist 68(2): 424-429.

Gelwicks, G.T, K. Graham, and D. Galat. 1996. Status survey for sicklefin chub,sturgeon chub, and flathead chub in the Missouri River, Missouri. Final Report. Missouri Department of Conservation, Columbia, Missouri. 22 pp.

Grace, T.B. and W.L. Pflieger. 1985. Fish survey of the Missouri and Mississippi rivers.Missouri Department of Conservation, Columbia, Missouri. National Marine Fisheries Service Program 2-363-R, Project IV, Job I. 56 pp.

Grisak, G.G. 1996. The status and distribution of the sicklefin chub in the Middle Missouri River, Montana. Master's Thesis. Montana State University, Bozeman, Montana. 75 pp.

Hesse, L.W. 1994. The status of Nebraska fishes in the Missouri River, 5. Selected chubs and minnows (Cyprinidae): sicklefin chub (*Macrhybopsis meeki*), sturgeon chub (*M. gelida*), silver chub (*M. storeriana*), speckled chub (*M. aestivalis*), flathead chub (*Platygobio gracilis*), plains minnow (*Hybognathus placitus*), and western silvery minnow (*H. argyritus*). Transactions of the Nebraska Academy of Sciences, 21:99-108.

Ludwig, J.A. and J.F. Reynolds. 1988. Statistical Ecology. John Wiley and Sons, New York. 337 pp.

Pflieger, W.L. 1997. The fishes of Missouri. Missouri Department of Conservation, Jefferson City. 372 pp.

Pflieger, W.L. and T.B. Grace. 1987. Changes in the fish fauna of the lower Missouri River, 1940-1983. Pages 166-177 <u>in</u> Community and evolutionary ecology of North American stream fishes. W. Matthews and D. Heins (eds.). University of Oklahoma Press, Norman, Oklahoma.

SAS Institute, Inc. 1995. Logistic regression examples using the SAS system, Version 6, First Edition. SAS Institute Inc.,Cary, North Carolina. 163 pp.

SAS Institute, Inc. 1990. SAS Procedures Guide, Version 6, Third Edition. SAS Institute Inc.,Cary, North Carolina. 708 pp.

Slizeski, J.J., J. L. Anderson, and W.G. Dorough. 1982. Hydrologic setting, system operation, present and future stresses. Pages 15-37 in L.W. Hesse, G.L. Hergenrader, H.S. Lewis, S.D. Reetz, and A.B. Schlesinger, editors. The Middle Missouri River. The Missouri River Study Group, Norfolk, Nebraska.

Tibbs, J.E. 1997. Flathead chub (*Platygobio gracilis*) status assessment. University of Missouri, Columbia, Missouri. Prepared for U.S. Fish & Wildlife Service under contract 1448-33410-97-M002. 47 pp.

Werdon, S.J. 1993a. Status report on sicklefin chub (Macrhybopsis meeki) a candidate endangered species. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 41 pp.

Werdon, S.J. 1993b. Status report on sturgeon chub (Macrhybopsis gelida) a candidate endangered species. U.S. Fish and Wildlife Service, Bismarck, North Dakota. 58 pp.

Zar, J.H. 1984. Biostatistical analysis. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.718 pp.

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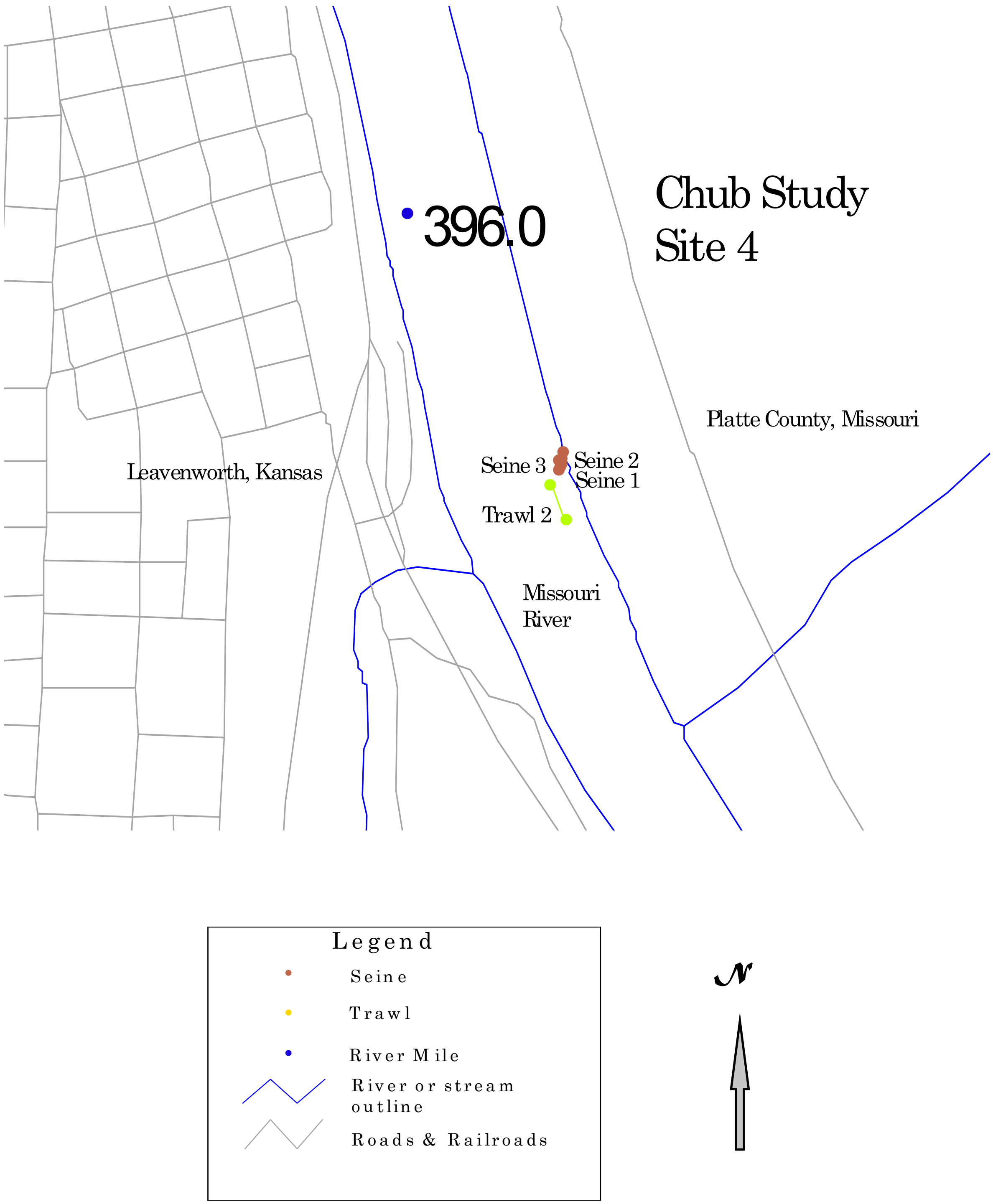
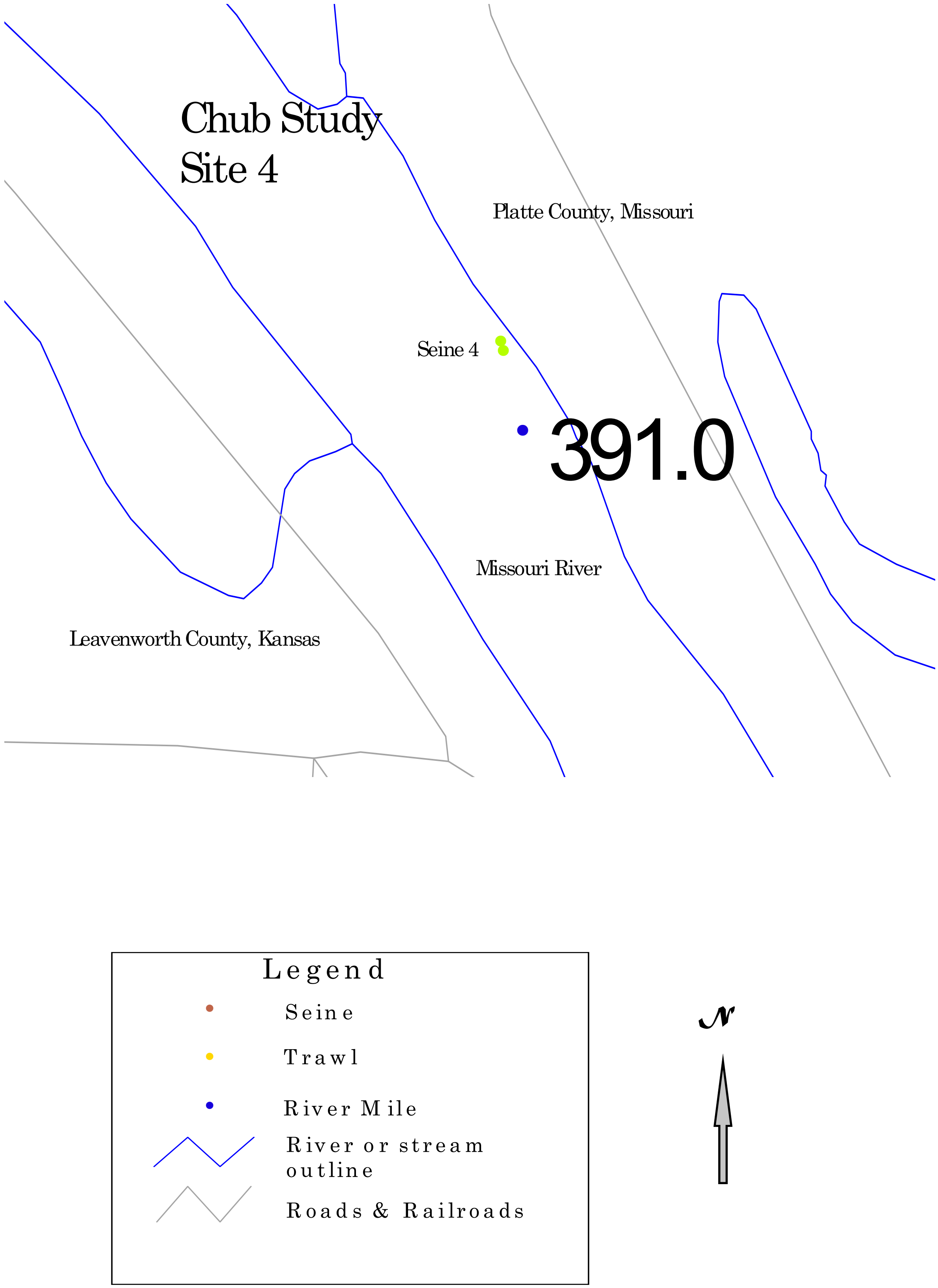
Appendix A

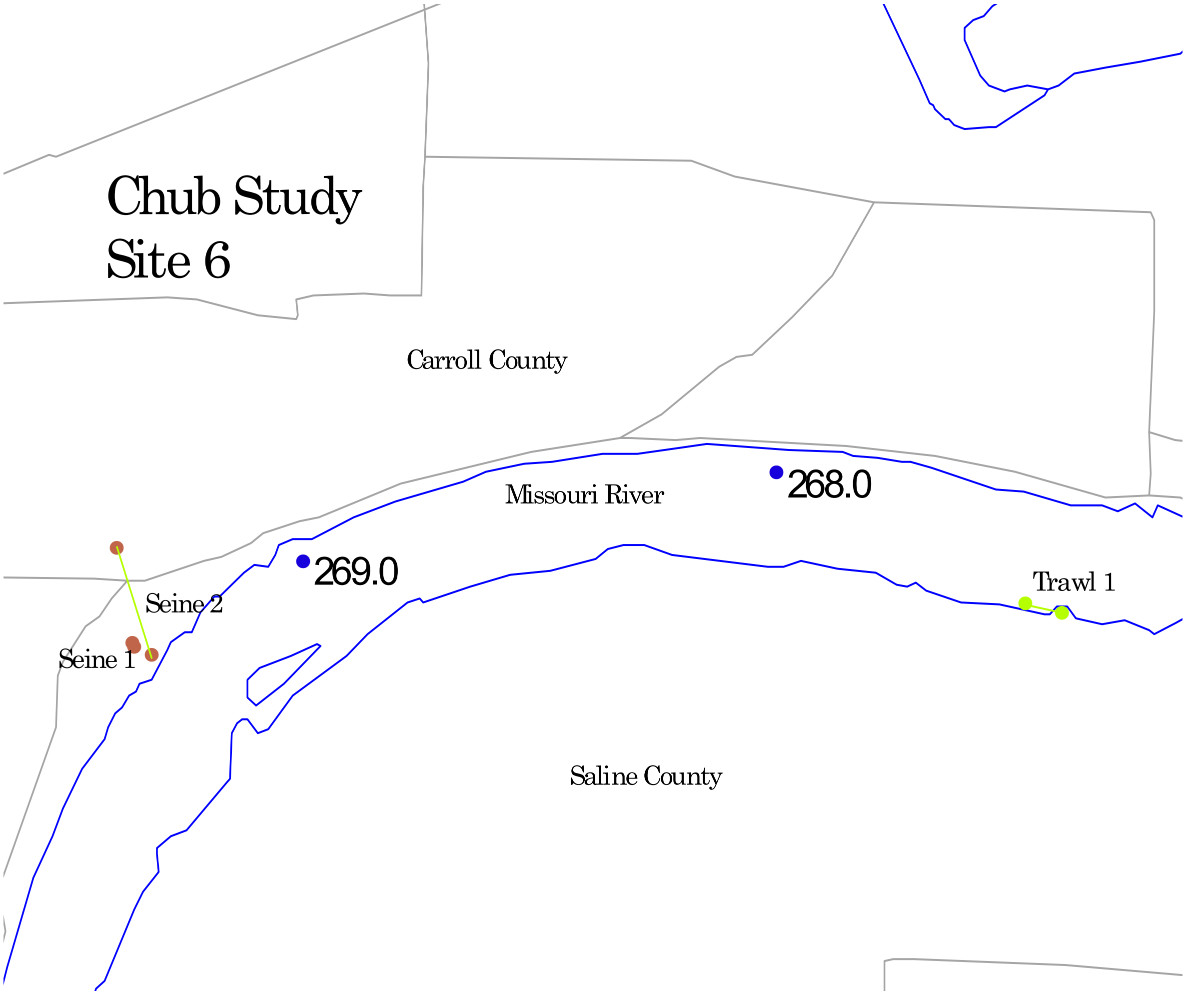
Maps of individual Study Sites

Chub Site 4, Missouri River / USFWS

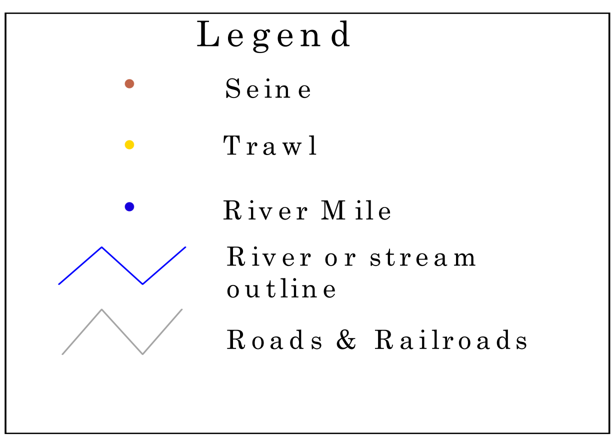


The following maps are preliminary in nature and are included to provide an approximate location of sampling efforts. Some seine locations will appear to be located outside of the river channel. This is due to a variety of reasons including: age of the base map, high water during sampling, and GPS unit error. The data were also collected in a different map datum and a different

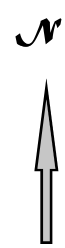

Chub Study
Site 4
Platte County, Missouri
Seine 4
391.0
Missouri River
Leavenworth County, Kansas
Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads
N



Chub Study
Site 6
Carroll County
Missouri River
268.0
269.0
Seine 2
Seine 1
Trawl 1
Saline County



Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads



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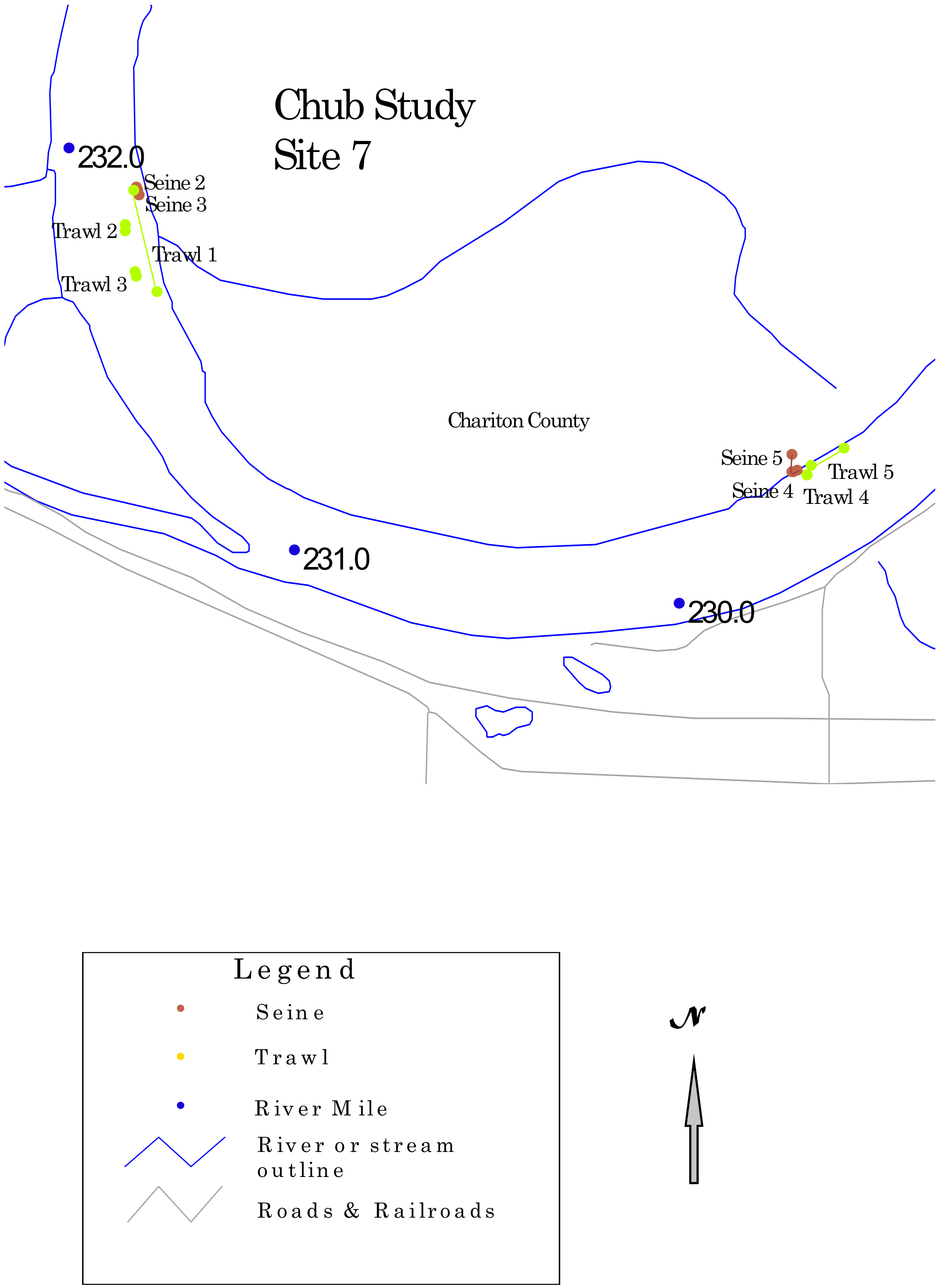
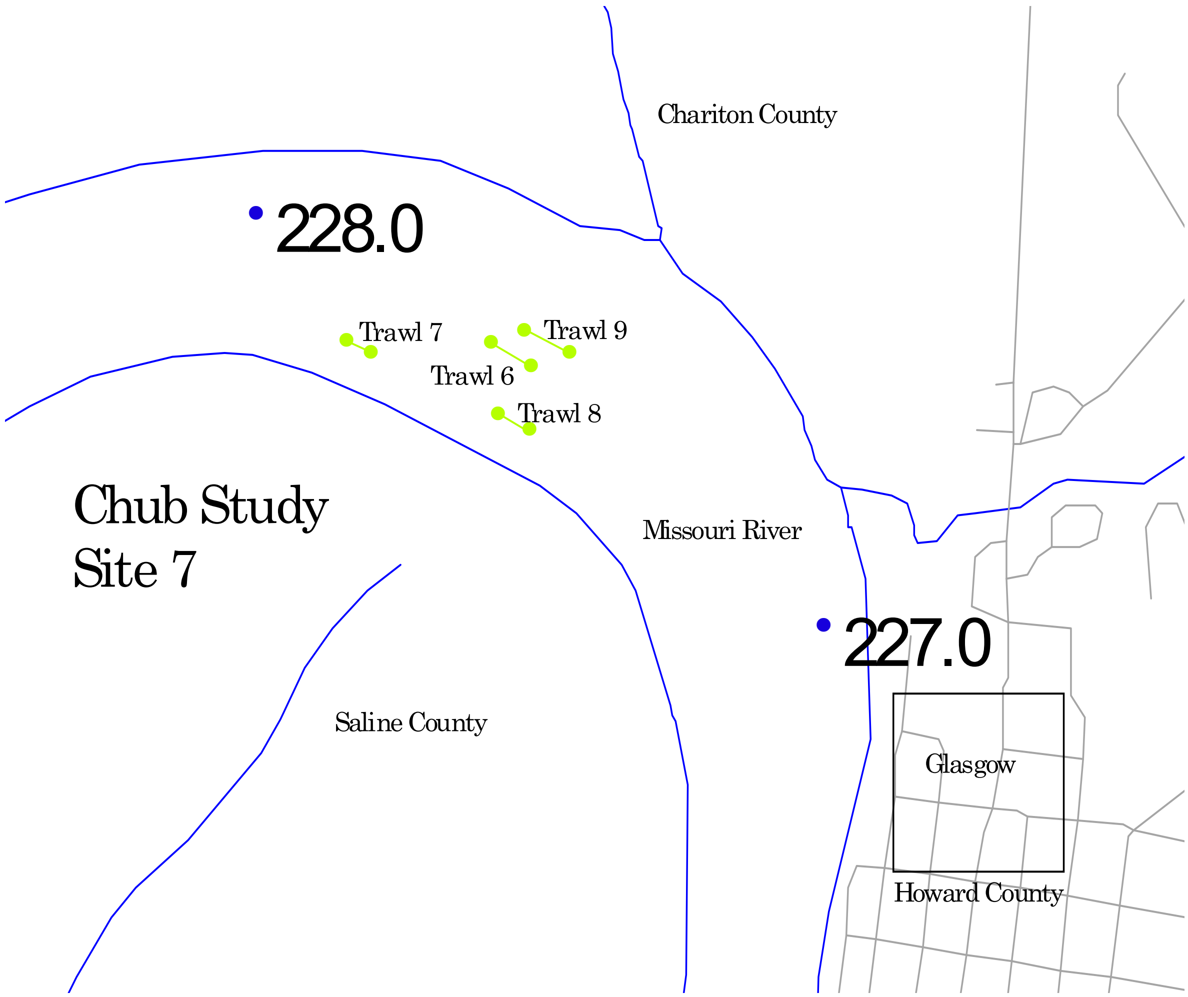
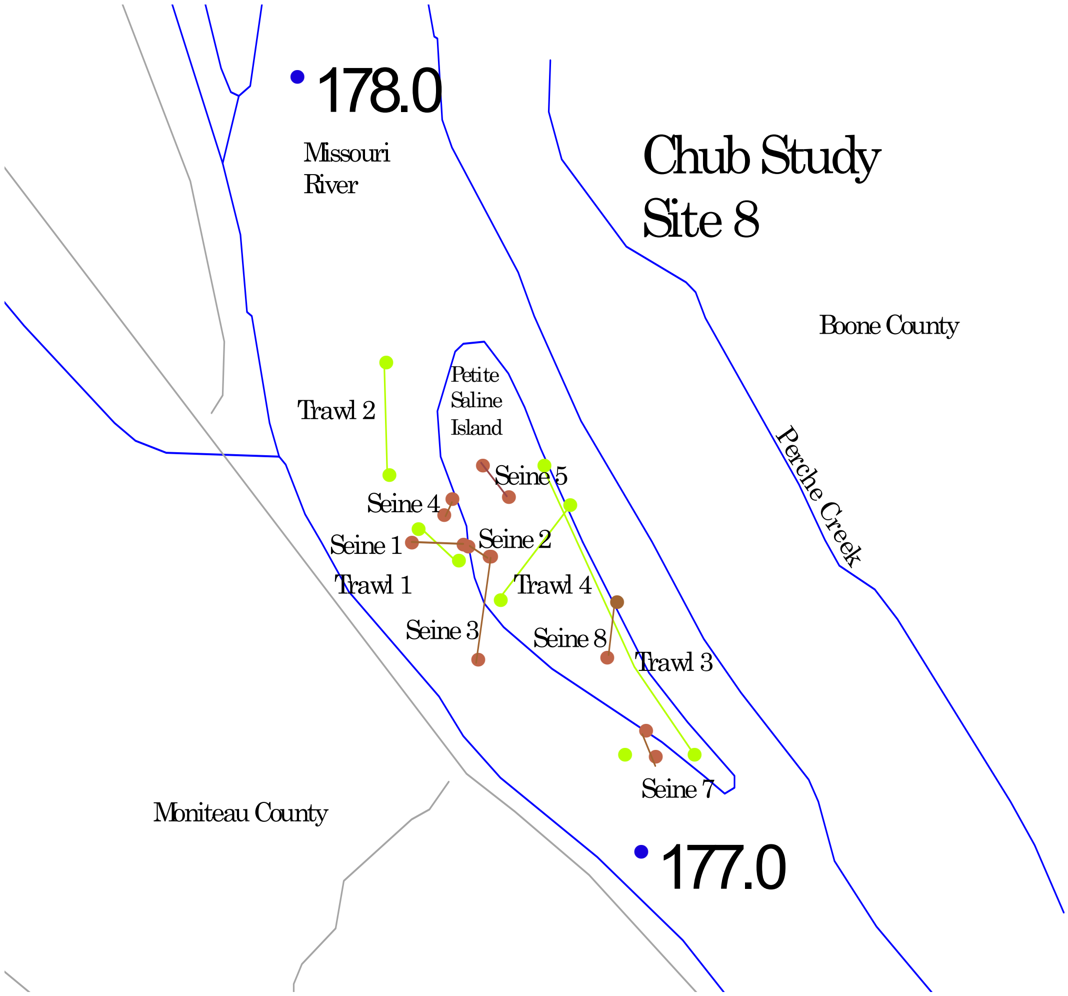
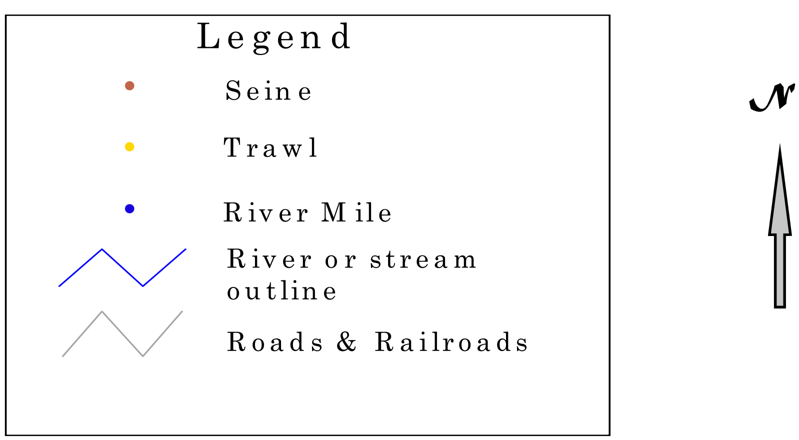

Chub Study
Site 7
232.0
Seine 2
Seine 3
Trawl 2
Trawl 1
Trawl 3
Chariton County
Seine 5
Trawl 5
Seine 4
Trawl 4
231.0
230.0
Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads
N

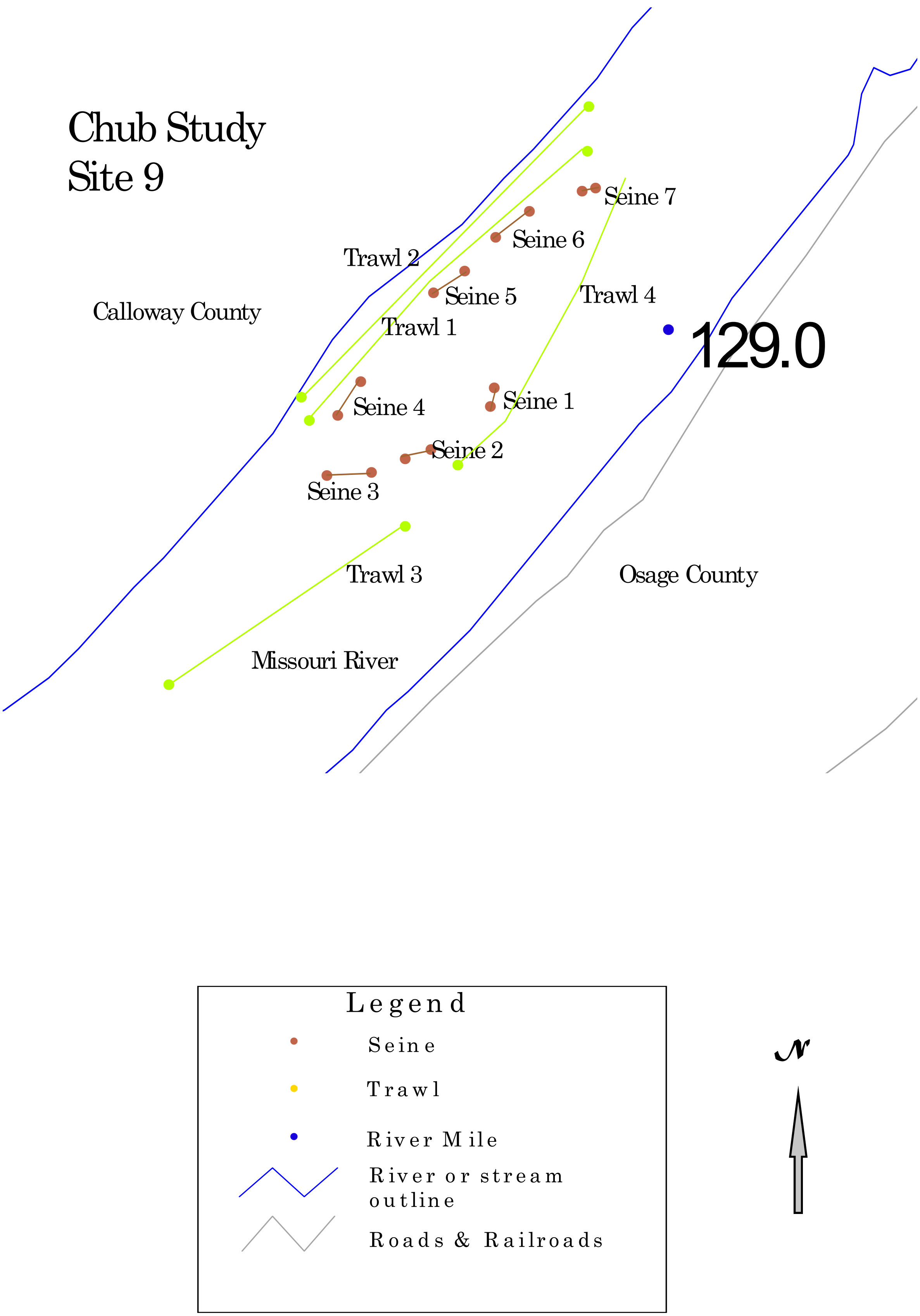

Chariton County
228.0
Trawl 7
Trawl 9
Trawl 6
Trawl 8
Chub Study
Site 7
Missouri River
227.0
Saline County
Glasgow
Howard County

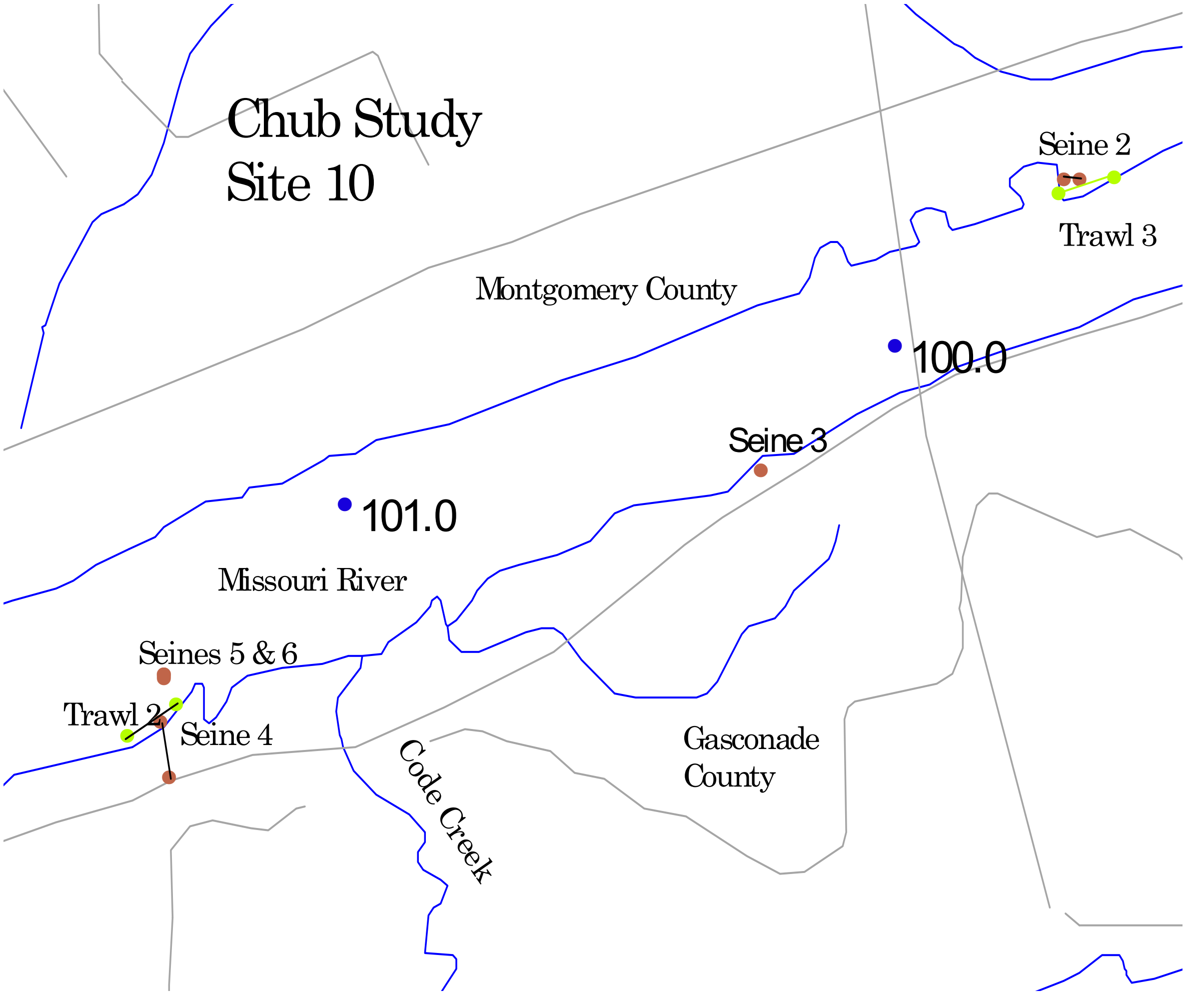

Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads
N

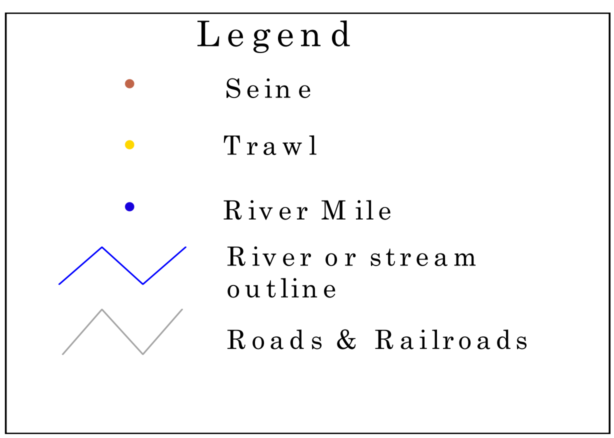

178.0
Missouri River
Chub Study Site 8
Boone County
Petite Saline Island
Trawl 2
Perche Creek
Seine 5
Seine 4
Seine 1
Seine 2
Trawl 1
Trawl 4
Seine 3
Seine 8
Trawl 3
Seine 7
Moniteau County
177.0

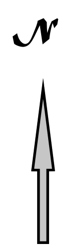

Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads
N

Chub Study
Site 9




Chub Study
Site 10
Seine 2
Trawl 3
Montgomery County
100.0
Seine 3
101.0
Missouri River
Seines 5 & 6
Trawl 2
Seine 4
Code Creek
Gasconade
County


Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads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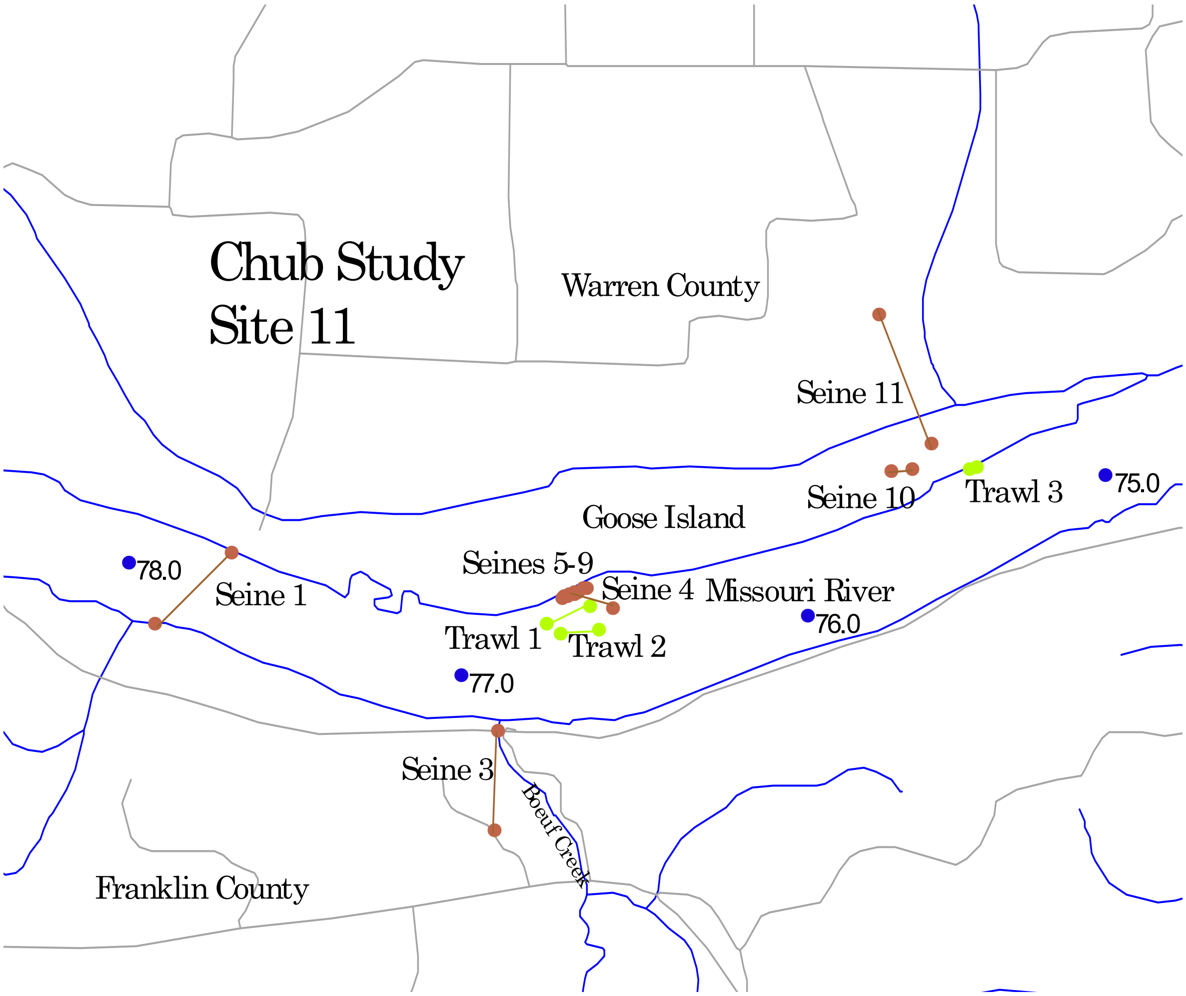


Legend

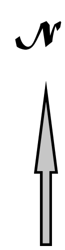
Seine

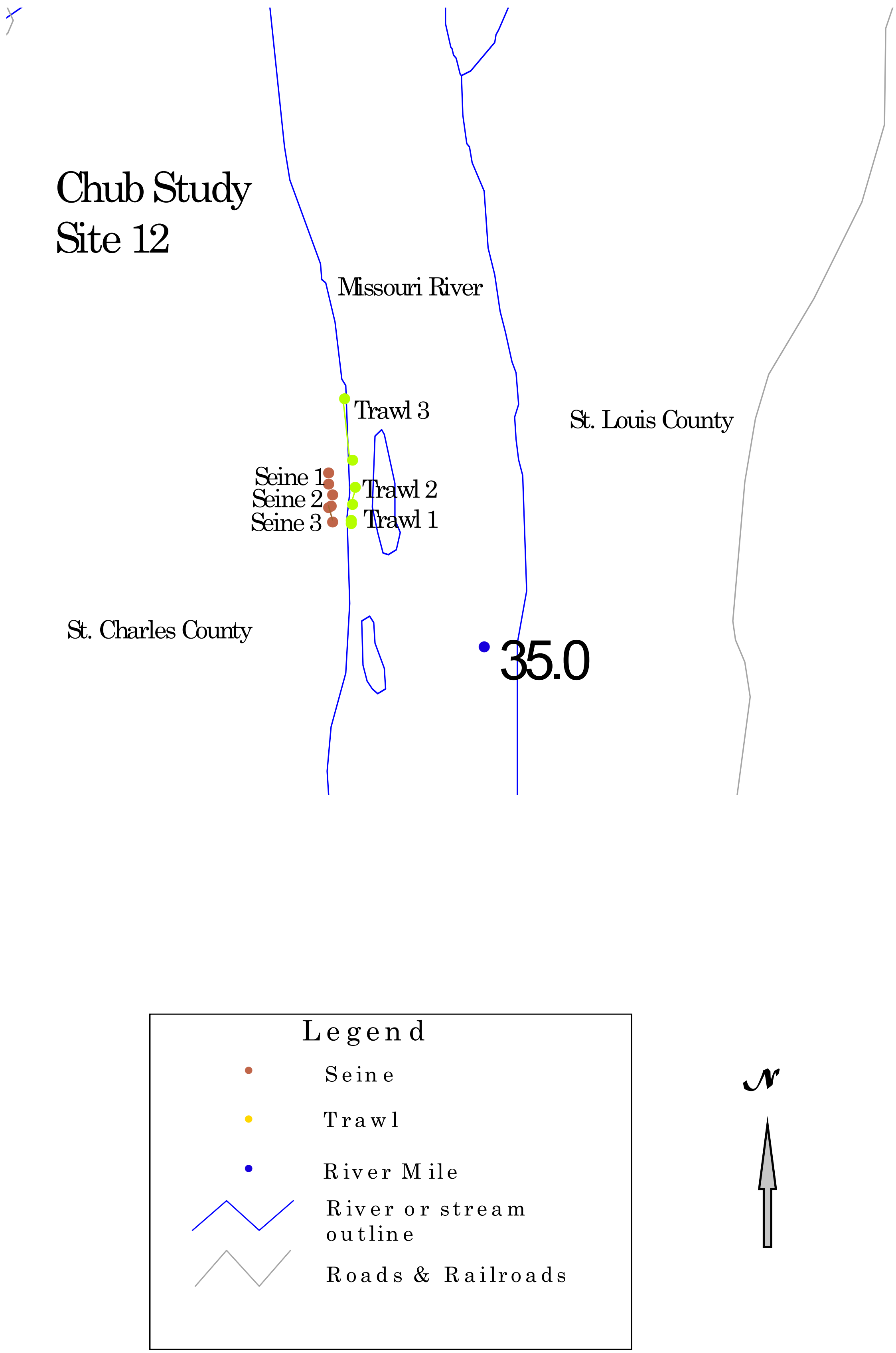
Trawl

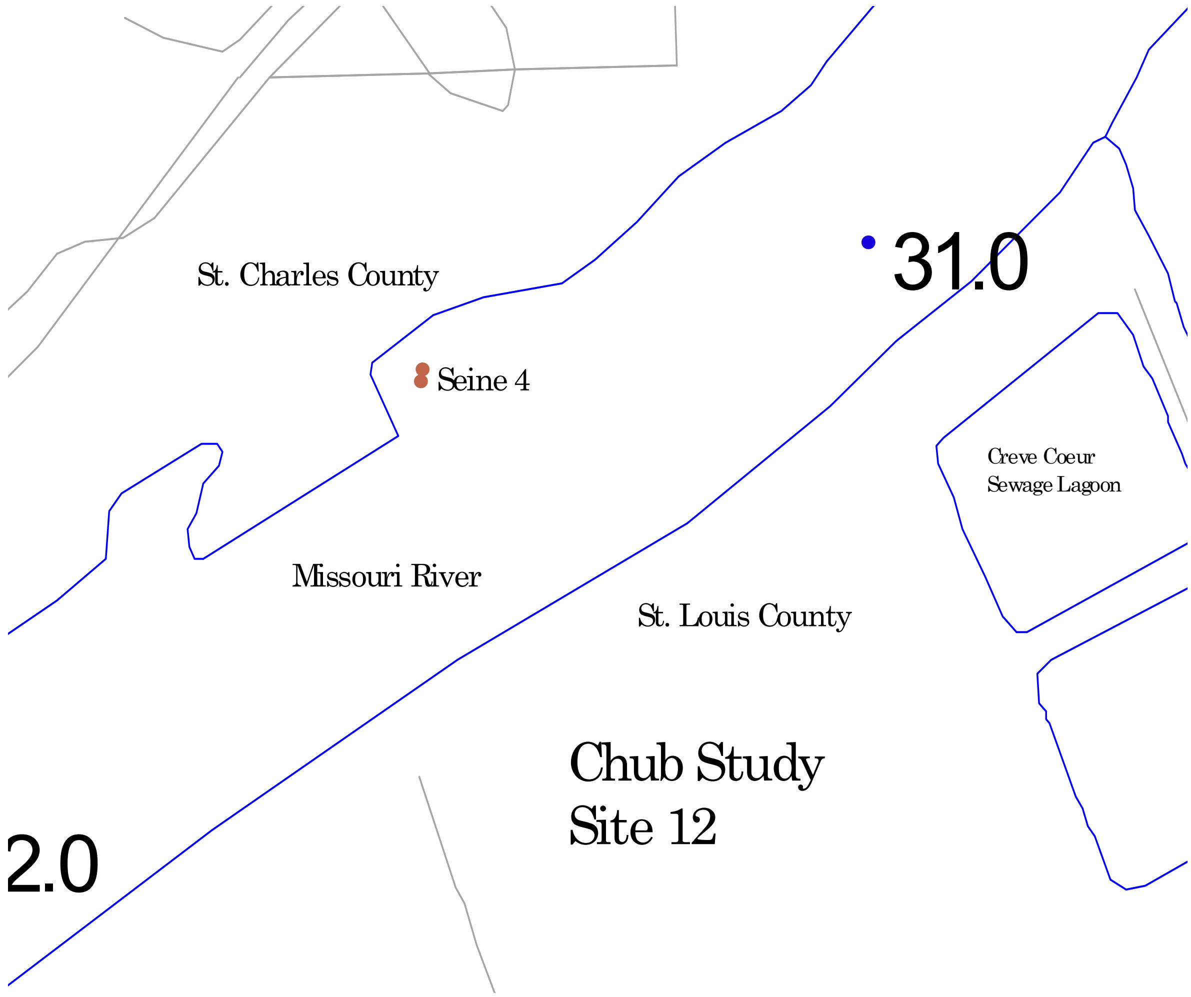
River Mile

River or stream outline

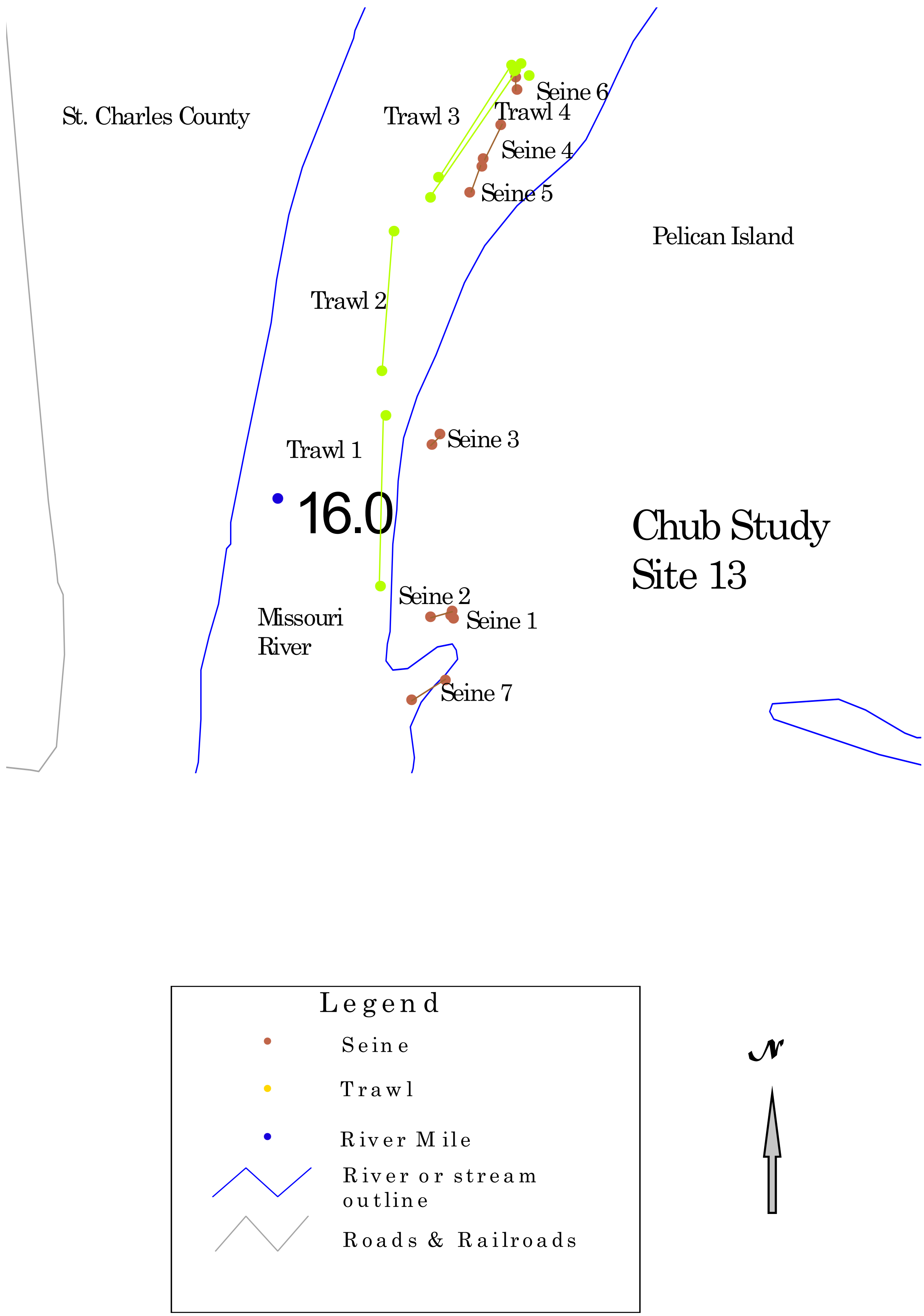
Roads & Railroads

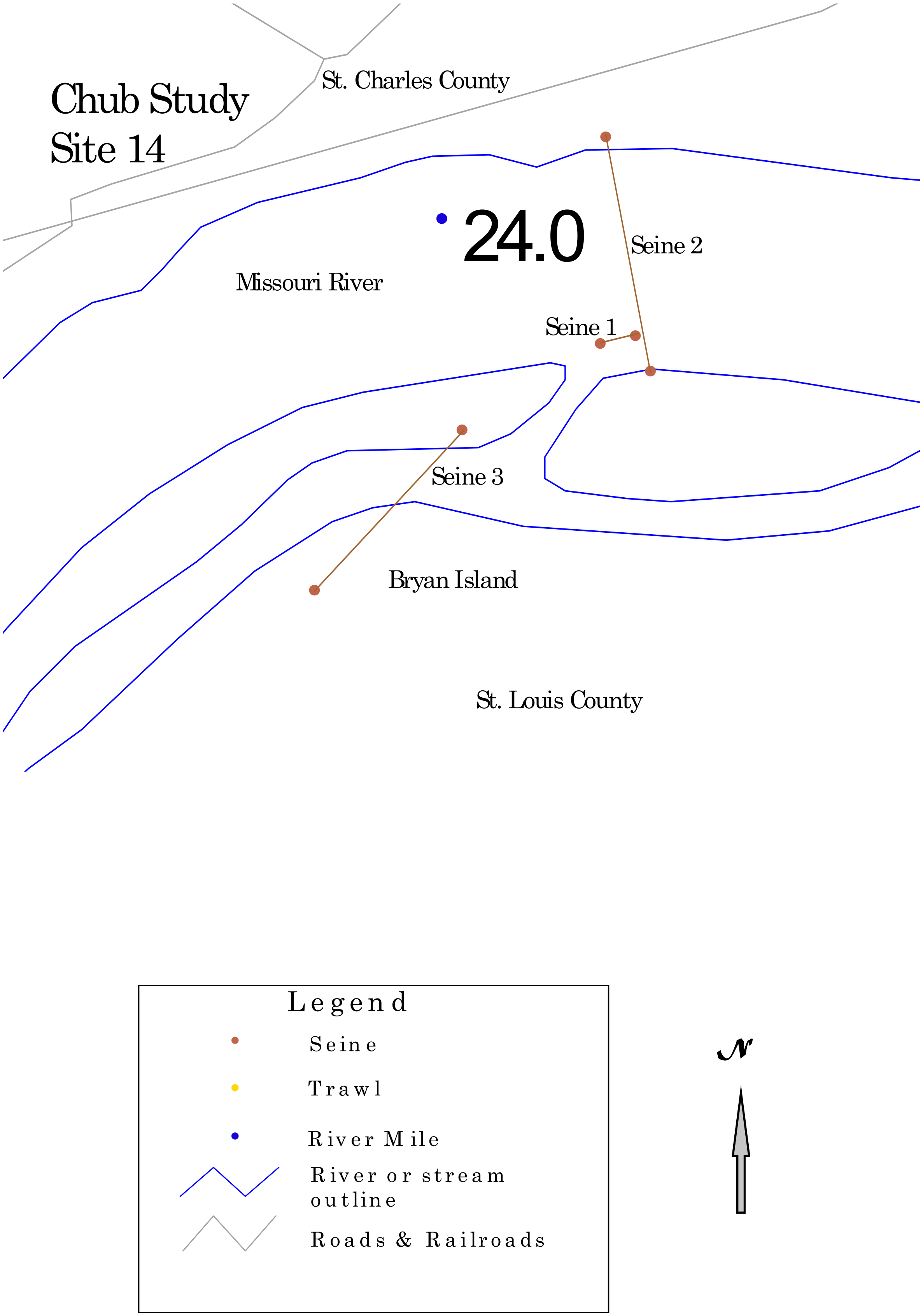


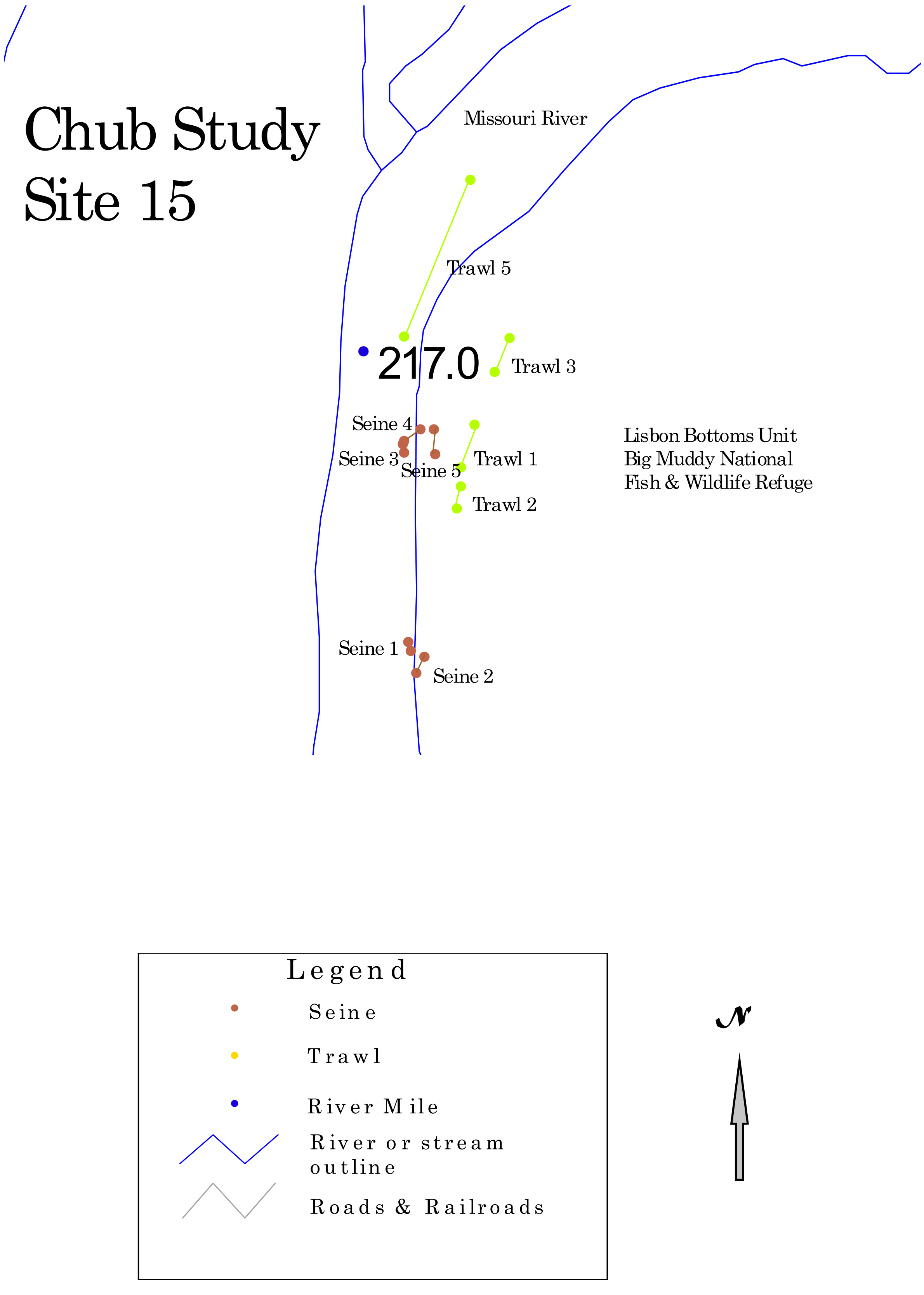

Chub Study
Site 12
Missouri River
Trawl 3
St. Louis County
Seine 1
Seine 2
Seine 3
Trawl 2
Trawl 1
St. Charles County
35.0
Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads
N


St. Charles County
31.0
Seine 4
Creve Coeur
Sewage Lagoon
Missouri River
St. Louis County
Chub Study
Site 12
2.0


Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads
N


St. Charles County
Trawl 3
Trawl 4
Seine 6
Seine 4
Seine 5
Pelican Island
Trawl 2
Trawl 1
Seine 3
16.0
Chub Study
Site 13
Seine 2
Seine 1
Missouri
River
Seine 7
Legend
Seine
Trawl
River Mile
River or stream
outline
Roads & Railroads
N


Chub Study
Site 14
St. Charles County
24.0
Seine 2
Missouri River
Seine 1
Seine 3
Bryan Island
St. Louis County
Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads
N


Chub Study
Site 15
Missouri River
Trawl 5
217.0
Trawl 3
Seine 4
Seine 3
Seine 5
Trawl 1
Trawl 2
Lisbon Bottoms Unit
Big Muddy National
Fish & Wildlife Refuge
Seine 1
Seine 2
Legend
Seine
Trawl
River Mile
River or stream outline
Roads & Railroads
N

Appendix B

Numbers of Sicklefin Chubs, Sturgeon Chubs, and Plains Minnows Presented as Percentages of Habitat Types, Substrates, Depths, and Velocities Sampled

Chub Site 12, Missouri River / USFWS

Table A1. Percentages of sicklefin chub, sturgeon chub, and plains minnows collected in each sampling habitat.

Location	Number of Collections	% of Collections with Sicklefin Chubs	% of Collections with Sturgeon Chubs	% of Collections with Plains Minnows
	Channel Bar Collections			
Head	3			67
Channel Side	15	20	7	40
Bank Side	18	17		44
Tail Side	3			33
	Connected Bar Collections			
Head				
Channel Side	13	23	8	46
	Main Channel Collections			
Unstructured	6	17		33
With Wing Dykes	19	5		32
With Revetments	3			
	Other Collections			
Backwater-Shoreline	3	33		33
Sidechannel Border	3			67

Table A2. Percentages of sicklefin chub, sturgeon chub, and plains minnows collected in each sampled substrate.

Dominant Substrate	Number of Collections	% of Collections with Sicklefin Chubs	% of Collections with Sturgeon Chubs	% of Collections with Plains Minnows
sand	35			63
gravel/rock	5	60	20	
silt	9	22		22
organic matter	6	50	17	22
missing values	31	13		29

Table A3. Percentages of sicklefin chub, sturgeon chub, and plains minnow collected in each velocity category sampled.

Average Velocity (m/s)	Number of Collections	% of Collections with Sicklefin Chubs	% of Collections with Sturgeon Chubs	% of Collections with Plains Minnows
less than 0	14	7		43
0-0.2	27	7		56
0.21-0.4	17	6		53
0.41-0.6	5	20		40
0.61-0.8	6	67	17	17
0.81-1.0	5	40	20	
1.01-1.2	2			
missing values	10	10		10

Table 4A. Percentages of sicklefin chub, sturgeon chub, and plains minnows collected in each depth category sampled.

Average Depth (m)	Number of Collections	% of Collections with Sicklefin Chubs	% of Collections with Sturgeon Chubs	% of Collections with Plains Minnows
0-0.5	32			69
0.51-1.0	24	4		46
1.01-1.5	5	80		20
1.51-2.0	13	38	15	
2.01-2.5	6	17		
2.51-3.0	3	33		
3.01-3.5	3			

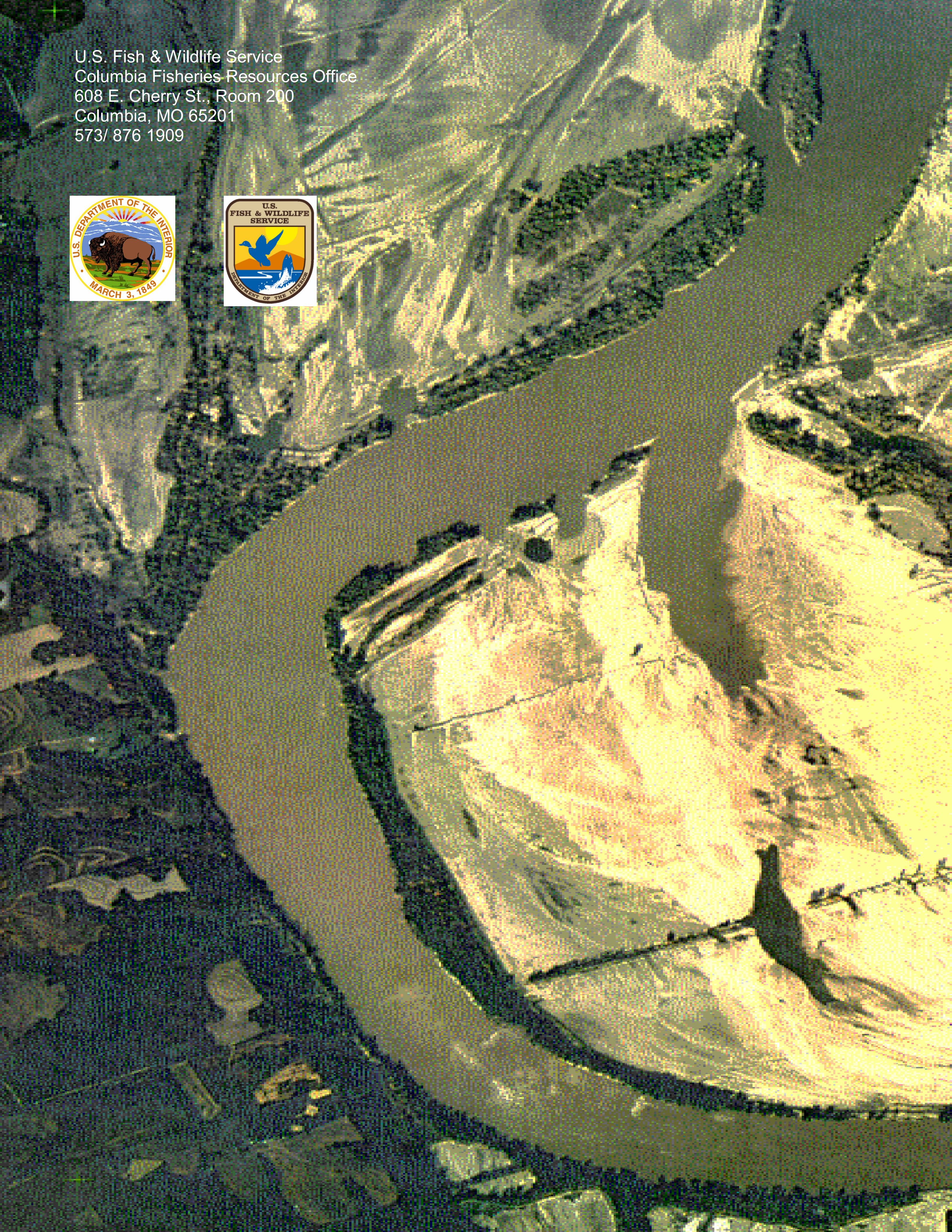
Appendix C

Numbers of Fishes Collected Represented as Numbers per Area Seined and Numbers per Volume Trawled

Chub Site 10, Missouri River / USFWS

Table C1. Numbers of fish collected by area (fish/m^2) in seines and by volume (fish/m^3) in benthic trawl samples in the Missouri River, Missouri from July 24, 1997 to August 28, 1997.

Species	Site 4 391.0-395.0		Site 6 262.2-262.9		Site 7 231.9-262.9		Site 8 177.3-177.0		Site 9 129.8-129.1		Site 10 100.8-99.5		Site 11 77.6-75.1		Site 12 34.9-31.3		Site 13 16.3-16.2		Site 14 24.5-23.7		Site 15 213.0-212.0		TOTALS	
	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl	Seine	Trawl
Blue Catfish						1.89				2.61		5.66						1.54						11.71
Bigmouth Buffalo									0.15														0.15	
Bluegill					0.56																		0.56	
Bigmouth Shiner					0.56																		0.56	
Bluntnose Minnow															0.30		0.45	0.31	0.76				1.51	0.31
Brook Silverside													0.49										0.49	
Common Carp							0.20		0.38										0.17				0.75	
Channel Catfish	0.53	9.59		24.78	0.17	33.80		15.81	3.44	43.92	1.86	74.47	0.11	0.47	0.39	2.82	0.36	8.98	0.51		2.91		10.29	214.63
Central Stoneroller													0.32										0.32	
Emerald Shiner	13.95		1.79		3.81		0.93		1.21		3.95		5.43		22.96		2.01		0.20		23.40		79.66	
Flathead Catfish						2.70		1.12		0.37		0.63			0.39	2.82							0.39	7.64
Freshwater Drum	0.53		0.67	3.20		1.62	0.06		4.01												7.60		12.88	4.82
Ghost Shiner									0.57														0.57	
Goldeye										0.16	57.80	0.63	0.75					0.31					58.54	1.09
Golden Redhorse											3.73												3.73	
Green Sunfish			0.04										0.11								0.70		0.85	
Gizzard Shad	0.99		4.06		7.09		9.34		18.94		37.17		30.95		191.711		20.24		16.04		2.51		339.04	
Hybognathus spp.							0.10																0.10	
Shovelnose Sturgeon						1.89				1.81				0.47				0.31						4.47
Longnose Gar			0.04				0.36						0.11										0.51	
Mosquitofish									0.57		0.25				1.14								1.97	
Plains Minnow	41.54		0.56		4.68		3.04		30.66		16.04		11.88		0.76		64.28		0.38		19.14	2.88	192.96	2.88
River Carpsucker	6.92		0.56			1.62	11.68	0.35	12.63		270.85		0.65		44.96		154.40		4.84		39.48		546.98	1.97
Red Shiner	2.06				1.09								0.62		0.39		13.65				0.23		18.02	
River Shiner	0.53						0.16				0.08						0.69						1.47	
Sauger	1.03																						1.03	
Sand Shiner	35.55		1.16		0.34		0.40				3.73		0.20		2.98		1.11		0.72		2.23		48.42	
Spotfin Shiner	0.49																						0.49	
Sicklefin Chub						2.32				6.28		8.81		1.40	0.39			1.23					0.39	20.04
Skipjack Herring																			0.38				0.38	
Silver Chub	5.35	0.80		0.80					1.15		0.08		0.06		0.60				1.91		0.36		9.50	1.60
Shortnose Gar					0.41																		0.41	
Spotted Bass											0.08		0.11				0.45						0.64	
Speckled Chub						0.27		0.49		0.14														0.90
Sturgeon Chub						7.57				0.19														7.75
White Bass	1.01						0.91		0.29				0.06		1.17				0.38		0.23		4.05	
unidentifiable fish												0.63												0.63
TOTALS	110.49	10.39	8.88	28.77	18.72	53.69	27.19	17.77	74.00	55.48	395.62	90.83	51.85	2.33	268.13	5.63	257.63	12.66	26.30	0	98.78	2.88	1337.61	280.45



U.S. Fish & Wildlife Service
Columbia Fisheries Resources Office
608 E. Cherry St., Room 200
Columbia, MO 65201
573/ 876 1909